ENGINEERING

An Illustrated Weekly Journal

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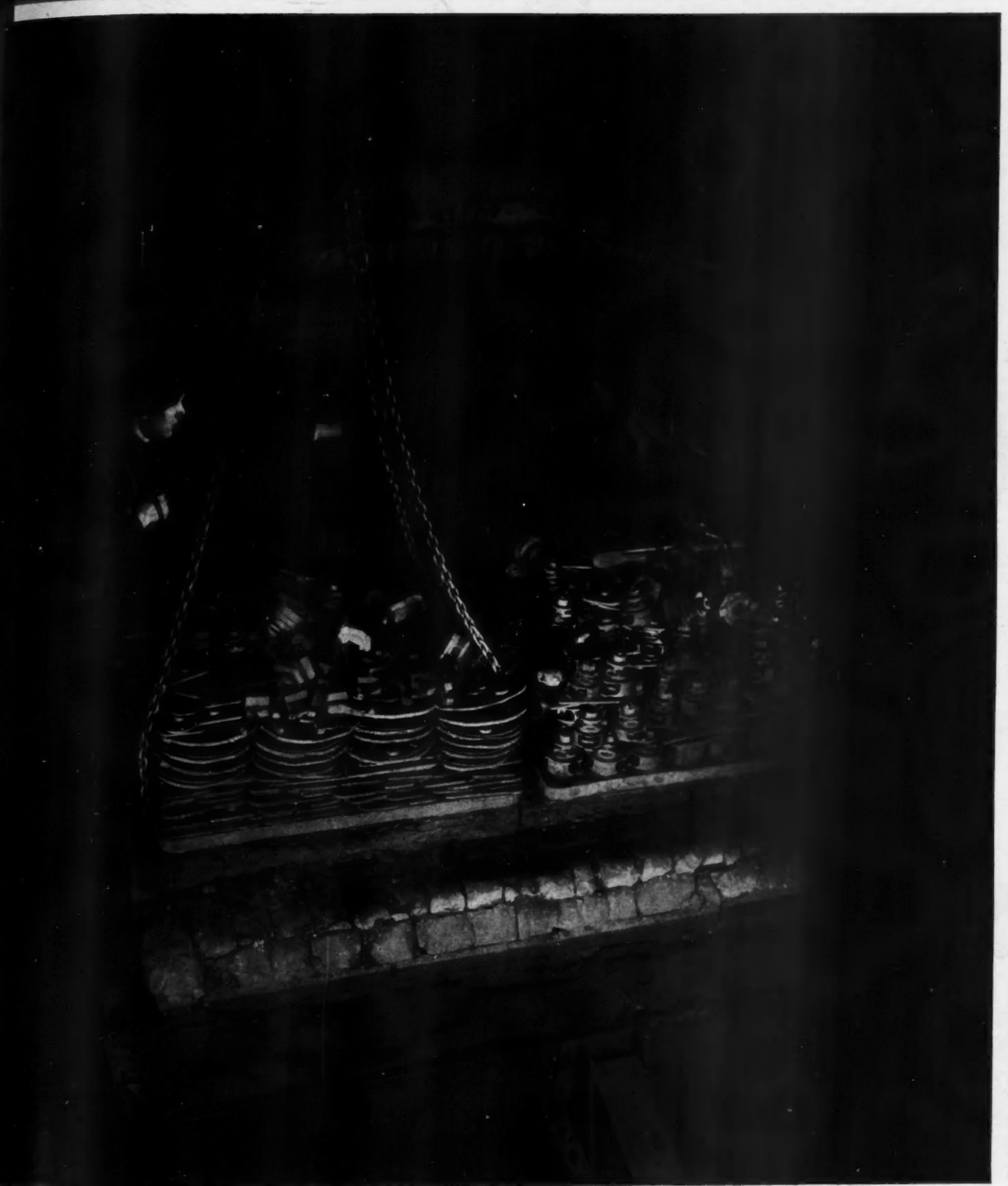

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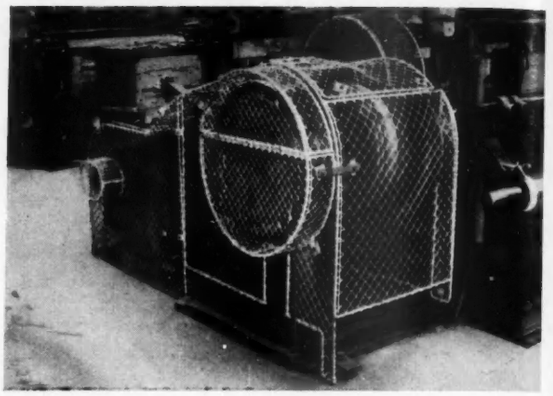

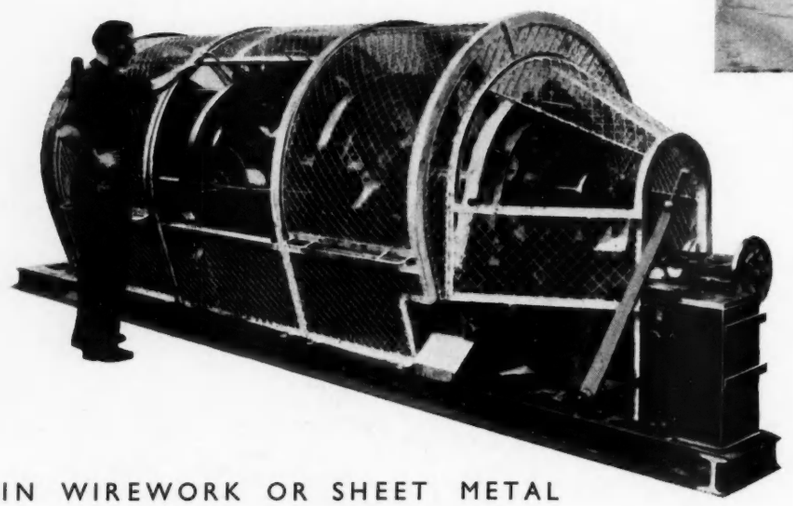

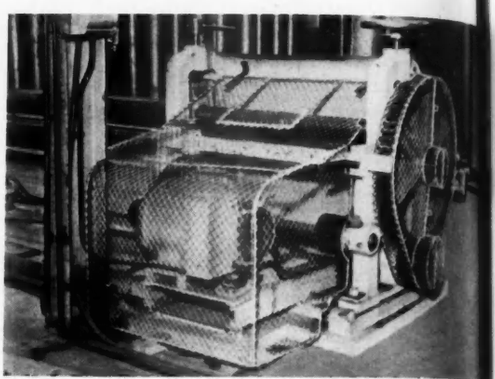

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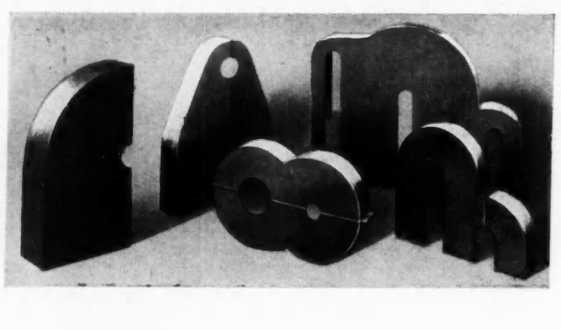

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An Illustrated Weekly Journal

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INDEX TO "ENGINEERING"
Volume 180 now ready

The Index to Volume 180 (July-December, 1955) is now ready and will be sent to any reader, without charge and postage paid, on application being made to the Publisher, 35 and 36 Bedford-street, London, W.C.2. Any reader wishing to receive regular copies of the Index as they are published can apply to be put on the mailing list. Those already on the mailing list need not re-apply.

BODY BEAUTIFUL

THERE is still a vocal minority of motorists in Britain who maintain that the only perfect cars, at least in outward appearance, were those classic creations of the 1920's now known as vintage cars. But in an industry where tooling costs dominate design the manufacturers cannot afford to cater for minorities, except in the production of sports cars. Body styling is now at least as important as mechanical efficiency, and where a manufacturer succeeds in surpassing his competitors in both respects he is likely to scoop the market. Motorists to-day are susceptible to curves in the right places, no doubt as a result of the barrage of visual enticements which reach everyone with eyes to see, from television screen and popular Press. Vulgarity and refinement are to be seen in car design, too.

The Motor Show high-lights the great and growing gap between the conception of car design current in the United States and the ideas of the rest of the world; reflecting the higher living standards, better roads, higher outputs and lower fuel costs prevailing on the other side of the Atlantic. The American's task is to maintain high sales in a market already well supplied with cars, and outputs which exceed a million a year for the most popular makes enable him to design for obsolescence, working to a two-year model cycle, with a major face-lift in the intervening year. In this way he can quickly render existing cars obsolete and encourage frequent renewals.

The European designer, with markets limited by lower living standards and, particularly in England, by high taxation and inadequate roads, cannot hope to see tool costs amortised on less than a five-year model cycle, and cannot make extensive modifications in between. He must therefore try to distinguish the important long-term trends from the flamboyant digressions when studying American design.

The steady interchange of ideas between American and Italian stylists has produced very interesting results, some of which are applicable to other cars. The car remains fundamentally a steel container to carry people and their luggage, but it is being given new variety in form and finish. The American Ford group is featuring the "Sculptured Look" for 1957, breaking up the areas of panelling by clever juxtaposition of concave and convex areas, of curves and hard angles, to give variety without extensive use of chromium plated ornamentation. New processes now allow rolled and embossed aluminium sheet to be given the appearance of gold or chromium plate, and these are being used, notably by General Motors and Hudson, to introduce new variety to exterior surfaces by covering some areas with a sheet of this treated metal. In very thin gauges it also takes its place in interior decoration, on instrument panels and the insides of doors. Radiator grilles are no longer so aggressively heavy and bright; matt-finish anodised grilles are being used by the Chrysler group, and some relief from the deficiencies of chromium plating of the usual commercial standard is promised by aluminium grilles finished to resemble chromium and already in use by some British manufacturers.

The other notable trend, well advanced on both sides of the Atlantic, is the extension of glass areas to provide full all-round vision. This of course means the elimination of some pillars, and the reduction of others to the minimum which can support the roof. The old "turret top," so powerfully plugged as a protection for the occupants in the event of a car rolling over, is heard of no more. Safety is being sold in terms of shock-proof door locks, padded instrument panels and visors, seat belts and drop-centre steering wheels, but the occupants have less protection than ever from being crushed in a car which rolls.

Safety features will undoubtedly influence body design, but there will still be plenty of scope for the body designer. Motor-car manufacturers reveal little of the basic principles, psychological or otherwise, which govern their designs. A few clues may, perhaps, be found in the article in this issue by Mr. Bentley Claughton, a sculptor who was previously an engineer. He distinguishes between two kinds of shapes—organic and inorganic. The best examples of organic forms are those provided by nature; they are forms which have grown, or developed by an evolutionary process. They are extremely complex in that they cannot be described simply in terms of straight lines, geometric curves or mathematical equations; but they are beautifully simple in that they are perfectly made for their function. Inorganic forms, on the other hand, are simple in that they are readily laid out on the drawing board; just because they use straight lines and the common geometric shapes they are compromises, and because they are compromises they can readily be machined.

The inorganic shape is often satisfying in the case of a mechanical component such as a connecting rod, but a too geometric shape for an outward form—a car body, say—can be very dull. It is no accident that the "Sculptured Look" has appeared in the United States. Are the concave and convex forms specified by conventional drawing offices means—are they therefore inorganic—or are they literally modelled in clay or some other medium so as to be organic and then

copied by production engineering methods? The inorganic approach is more likely, if only for ease of manufacture.

Where does the German Volkswagen fit into all this? No one would call it beautiful, but its sales have exceeded all expectations. It is like the woman your friend decides to marry: she is very ordinary looking, you don't know what your friend saw in her, but she turns out to be an excellent wife. Beauty is exciting at a distance, but to live with, to drive—maybe most people prefer something more like themselves. Car design is a subtle business.

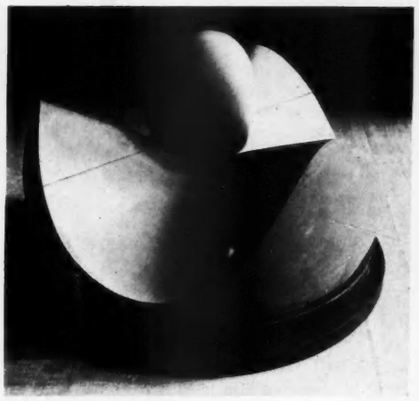
* * *

Plain Words

It is an odd fact that large schemes of improvement and modernisation which are apparently "essential" to the country's welfare are so often postponed indefinitely. During a slump there are obvious reasons for not being able to do anything. In boom times the consumer seems to dominate the pattern of production, with all his demands for frivolous luxuries, and the inflation that accompanies the boom inevitably forces the government to curtail capital expenditure in the fields over which it has direct control. Hence the neglect of road and rail. When British Railways were given their modernisation charter early last year, high on the list of priorities was the equipping of freight vehicles with continuous brakes. As the vacuum brake was already in general use the Transport Commission decided to extend its use to all rolling stock, rather than face the upheaval involved in changing over to air brakes. There has been much argument over this decision. There is now little likelihood of the decision being reversed, but is there anything to be learnt from the situation which gave rise to the argument?

A study of the relative costs, to British Railways, of both types of brake, and of the technical efficiencies, was prepared by Sir Charles Goodeve, director of the British Iron and Steel Research Association, earlier this year. He concluded that, from the operating point of view, almost every advantage and disadvantage of the two types balanced out, except that there was considerable delay in releasing the vacuum brake. He considered that the extra cost of the air brake did not justify its adoption. The argument did not stop there, however; no doubt it will go on for years, as most railway arguments do.

There is now something much more vital to be learnt from this argument: the fact is that the change-over should have been made a generation ago. There are to-day so many other improvements waiting to be carried out that a compromise has to suffice for the delayed one. An extra effort is needed to tackle jobs that are "essential" now. There are innumerable cases of out-of-date plant, administration and practice that call for a vigorous approach by modern methods. The ability and knowledge are not lacking. The right climate of public opinion needs fostering.



MATHEMATICAL SURFACE: $xyz = k^3(x+y+z-1)^3$
Artificial Inorganic

THE SHAPE OF THINGS

By R. Bentley Claughton

Most of us on leaving school are already conditioned to thinking we know what career we are cut out for. Either we shine a little in a particular branch of our studies and a suitable occupation is insidiously implanted in our minds by conscientious school-masters, or by home influence it is automatically assumed that we do what father does, or equally automatically that we do not do as father does, according to how successful Dad is in his particular field. A few, a very few of us, know with unerring accuracy from roughly the age of three, exactly what we are going to make of our lives; we press quietly and steadfastly towards our goal in spite of parental threats and entreaties. From this group, I suspect, springs genius.

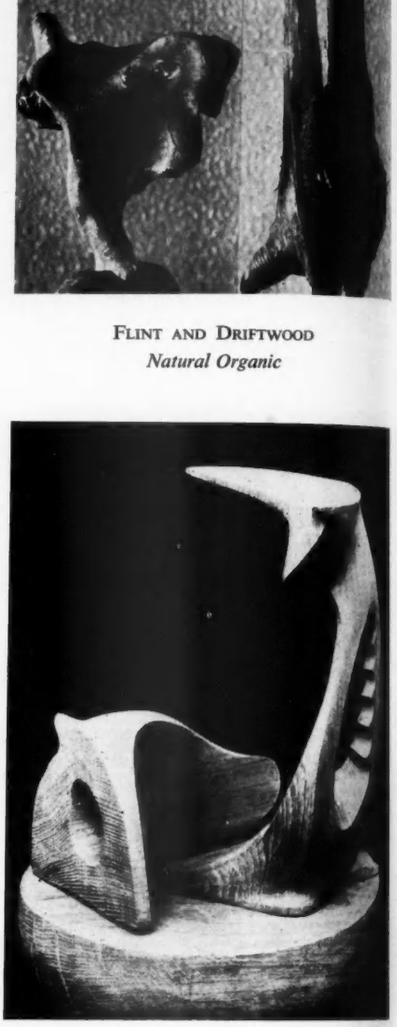
I was one of the others. The Maths. group got me into the least trouble at school and there was a congenital streak of engineering for a generation or so past in the family tree. Back beyond that were to be found traces of the Church, but as this only complicates the issue unnecessarily let us forget it.

So I took the obvious course—an engineering apprenticeship, after which, and this step was less obvious and caused a considerable amount of consternation at home, I took a year off for the sake of the entirely new experience of working on a farm, before settling down in a drawing office. This lapse was merely a pandering to the wanderlust that dogs most of us in our early twenties and not due to any lack of interest in my own subject. In fact, by this time Maths. fascinated me and, for that matter, still does. Once in a drawing office I resumed my swotting, enjoyed the work and was without any doubt that I should always be an engineer.

For a while I shared the studio of a painter friend who was responsible for opening my eyes to many visual pleasures, but at that time I had no idea of even dabbling in the arts, feeling that it would have been as presumptious to attempt any expression of my own as to try to compose an orchestral symphony. I may, however, have been influenced by this contact more than I realised, for I do remember having a considerable brush with a Chief Engineer who could see no justification for what I considered a rather handsome bit of casing-in, over a compressor unit. Fortunately the C.E. won. The compressor unit was much more pleasing to the eye than the casing in which I would have enshrouded it.

It was not until some years later, finding myself on the bleakest corner of the north-east coast of Scotland, that I surreptitiously started

FLINT AND DRIFTWOOD
Natural Organic



FISH GROUP IN OAK
Sculptured Inorganic

WILD GOOSE IN SYCAMORE
Sculptured Organic

to paint in my spare evenings. At first, small paintings of my surroundings but in colours that belonged to a far sunnier climate. Jazzing up the town, in effect. For it was a grey town: grey and cold and depressing. The buildings and streets were of granite, the sky usually leaden, and the few trees that grew there were bare and stunted and leaned permanently at a critical angle to escape a viscious wind which seldom let up. It was in self-defence against this colourless world that I painted, and when I felt that I had exhausted the town's visual possibilities I sat up at nights, toiling over great canvasses on my own inventions; hideously complicated figure compositions; paintings with a "message." They were pretty bad, but it's a long time ago now. Long enough to be able to admit to having done them. One of them is still in my possession—I keep it as an awful warning.

I admitted to myself that painting was merely supplying the need for colour in a colourless world and that the urge would die when I returned to England, but such is the disease that on my return I was so excited by the comparative brilliance that painting became even more urgent. Then, because I was looking at things critically for possibly the first time in my life, I grew interested in shape too and involved myself still further by experimenting in sculpture. Tentatively at first, working in the soft Cotswold stone with which my garden wall was built (this wall diminished considerably during my tenure), and later going to an art school for life study, on my free evenings.

During all this time I had kept very quiet about my secret vice in the firm in which I worked, and, feeling a little guilty about having such an all-consuming outside interest, I worked so hard at my job that I was given a section in the experimental design office and thereafter had little time during working hours to indulge myself with visual pleasures. Neither would I have wished to do so for I was still very interested in the job. But in spite of this I knew, by

FISH GROUP IN OAK
Mixture of Organic and Inorganic

degrees, that sculpture and painting were stealing up on me. By chance, just at the time that this realisation was formulating itself, I became acquainted with an old, old man who had been a successful architect many years before. So successful in fact that his family had grown used to the luxuries he was able to provide and so, in spite of a life-long urge to paint, he was unable to afford to make the break until he was forty. It was therefore only after that age (he was nearly eighty when I met him) that he was able to realise his ambition, cursing the lost years and painting furiously and desperately, with an immense pile of paintings in his studio on which was pinned a notice bearing the simple message—"Used Canvi." His fate quickened my resolve to make the change before I, too, became a disgruntled old man. I left engineering hurriedly and was accepted as a student at the Slade.

Even then I made a mental reservation that, as an artist, it was unlikely that I would be able to keep my family in even reasonable comfort, let alone luxury, and that once trained I would in all probability have to go back into engineering to earn my keep, relegating sculpture to that of a part-time occupation. Curiously enough I did not have to return. Not that (in terms of money) mine was an immediate success story. I would like to be able to say that commissions straightway came rolling in faster than I could execute them. In fact, my sales during the year immediately following my training totalled eight guineas—for one small oil sketch. It was a pretty nerve-wracking period financially; with monotonous regularity I set about planning how to sell the house each time the rates came round, and my son, each time his school fees fell due. However, with a great deal of grinding of the financial wheels the change was made from engineer to artist, and looking back I see that it was inevitable. Even if not at that precise time it would have crept up on me at some later stage in my life. It is rather like rheumatism; if you are susceptible it will catch up with you eventually.

The change was not an alarmingly drastic one. There is a surprisingly close relationship between the engineer and the artist, and even more particularly between mathematics and sculpture. The same mental processes produce both products so that I did not feel that my existence had been basically altered. I think now that the main difference is one of attitude to the economic structure of society rather than to the work itself. As an engineer, one can take and hold a job on one's knowledge, qualifications and experience. In the arts these are less provable. Qualifications prove little more than that an artist has satisfactorily achieved a certain standard of ability and technical proficiency. They do not state how good an artist he is. After that, he is on his own, experimenting for the rest of his life, and after each experiment being in a position to assess, only to his own satisfaction, how nearly he has arrived at a conclusion but never able to say "I know this is good art." There is only one's completed work to show and its intrinsic quality is imponderable. So the confidence of the knowledge that one is good at one's job is never present with the artist. On the other hand, in the actual "doing" many aspects are common to both fields. In both is the satisfaction of actually producing something. Art is not a copying of things seen but an attempt to understand their essentials and then a translation of them into another medium. As with engineering, it is a search for the simplest and most direct statement; a rejection of the inessential; an inquiry into basic truths. By his training the engineer has a consciousness of shape and volume and develops a discriminating eye for good proportion. He is accustomed to work with several unknown factors, and is equipped with a sequence or process mind. All of which are essential to the sculptor.

Is there then any fundamental difference between art and engineering? And if so, what is this difference? What exactly is the distinction between the aesthetic visual pleasure one experiences when looking at a satisfying piece of sculpture, and when confronted with a well designed car, or aircraft fuselage? This problem was ever present during the years immediately following my training. Especially as it was so obvious that, since the Industrial Revolution, artists had been strongly influenced by mathematical and geometric forms, and by the logical shapes found in engineering. It took a great many experiments before I crystallised the belief that it was fundamentally the difference between organic and inorganic forms that separated the two fields, and that it had been the logic of an inorganic shape that had appealed to the sculptor in his search for pure form. For example, a parabola is a satisfying curve because it is a sequential and constant mathematical curve and the path of a point travelling along it can be formulated in terms of x and y. In consequence, on seeing a section of one, we know in advance, quite instinctively, without even my knowledge of geometry, how it will progress. We get an intellectual pleasure from things that do as we expect. If we enlarge on this, and at some point along the parabolic curve insert, say, a segment of a circle, there is the initial shock value as our eye reaches the intersecting point and the change in direction, but once on the new track we are following again a logical sequence curve. This enjoyment of an expected sequence of the path of a point, and the stimulus of changing direction from one mathematical curve to another, are intellectual pleasures—a reassurance that things are as they should be—and these were being exploited considerably by sculptors, who were instinctively and quite logically drawing on these inorganic shapes: curves that could be calculated, or forms that could be laid out in three views on a drawing board. This was natural and legitimate. It was far easier to sustain the continuity of an arris (the sharp edge where two planes meet) on an inorganic form, and as we have already seen, the inorganic forms were immediately acceptable to the intellect.

For several decades, artists, caught up in the whirl of the machine age, and re-acting against the sentimental realism of the sculpture and painting surrounding them, used these geometric shapes. The change was a normal and healthy antidote to the literary guise that the visual arts had assumed, but their experiments were for the most part arid. They were abstractions of inanimate, inorganic shapes, and the visual pleasure they offered was immediate but transient.

Organic abstractions, on the other hand, are an acquired taste and take a lot more stomaching. By "organic" in this context I mean those forms which Nature would use in a particular set of circumstances, as opposed to those that would be used by logical Man. Let us say that the engineer has before him a surface bounded by its arris, or turning points. If he requires a hole through it he strengthens the surrounding material by means of a thickening of the rim round the hole on one or other of the surfaces, and possibly, too, by reinforcing flanges. He can show his requirements in two, or at most three, views on a drawing. Compare this with a hole-in-bone structure—an eye socket, for example, designed by nature to withstand a considerable load from several directions, with a stiffening flange winding through from one surface to the other, with an incredible economy of material and perfectly stressed up. But the perimeter of the aperture, although practical in shape, is completely unpredictable and quite impossible to design on a drawing board, to be worked from or translated as a mathematical formula. Each section of the curve is not as we anticipated. Our sensibilities are shocked into having to grasp a new visual experience. At first we are not even sure that we like it. Here then is an organic shape, a record of which can be carried in the mind only. It is just as logical as the inorganic form but logical in a different way. It takes more grasping than the immediate logic of the calculable curve and, inevitably, once the taste has been acquired, carries with it a greater and longer-lasting visual pleasure.

The segregation of these organic and inorganic forms was, I felt, the key to the artist-engineer poser. While engaged on this pre-occupation, I used fish forms as the basis of experimental compositions. Fish appeared particularly suitable victims as they could be treated in both ways, and my studio developed an aquarium-like atmosphere before the point arrived where I thought I could discriminate between art and science. These experiments were carried out some years ago. I am less certain now than I was then of the existence of any considerable difference. All the creative fields have a great

EAGLES FIGHTING

Shapes and Implied Movement Used Organically

deal in common. Each one of us has an urge to create and the way it is canalised is largely fortuitous. That it takes the form of science, music, sculpture, engineering or the planning of a garden, or for that matter, embroidering a tea cosy, matters not a jot. What does matter is the approach: providing that what one is doing is not merely a dull repetition of what has been done before, but is created with an awareness of what really makes things tick, one stands the chance of creating something that can enlarge the spectator's experience. This exploration of natural shapes and the understanding of the underlying purpose in nature is essential to the artist. How inadequately could he translate a sleeping puma for instance, if he had never seen a puma in any other position and was totally unaware that this relaxed shapeless mass housed so much controlled energy; that its shape was fashioned by the way it had to get its food; that its very existence depended on the power in those sinuous fore-paws.

For the artist, then, it is looking, understanding and translating; not just looking and reproducing. His development is a continuous experiment, or rather a series of experimental preoccupations, such as those described, leading, he hopes, to a greater understanding of fundamentals. He knows, just as the scientist knows, that his researches will yield only a small glimpse of eventual truth.

Rembrandt, as a very old man, expressed the wish that he might be spared for yet a further ten years so that he might reach an understanding of drawing! The artist knows, too, that his failure so often to make the statement he sets out to make is a failure to understand what he sees, not an inability to put down what he sees, and that the chance of transmitting some worthwhile aspect of the thing perceived is increased with each new discovery of the laws of natural phenomena.

All of these researches and preoccupations are a means to an end; a technical, intellectual peg, so to speak, on which to hang the emotive content of the statement he is trying to make. They can be described under the general heading of "study." Study goes on all his life. All this aggregate knowledge constitutes the tools-for-the-job. How he uses this knowledge selectively determines his worth as an artist, but in preparation he questions and examines every kind of natural phenomena. Every kind of organism and growing form must come under his scrutiny. It is necessary for him to understand each shape before he can use it effectively. Only then can he select or abstract those qualities which describe a shape most accurately. This power of selection is the filter for the information he has gathered.

The beginner is usually unselective. Watch him modelling a human head in clay, and for the most part he will try to reproduce it in its entirety, putting in features and even wrinkles before he has a considered shape to put them on to. It is rather like putting the knobs on a cabinet before the cabinet is built. Gradually, however, he learns to select the more important forms, omitting details until he is sure that they are helping, not hindering, his main statement. And so he continues to refine his main shapes until they are strong enough to take the minor forms. This method of working may lead him later in his development to select or abstract more and more, until he finds himself producing work so divorced from the original that it is unrecognisable to anyone who has not trodden the road with him. He sometimes finds that his preoccupations have led him further and further away from the truths of nature or, having thrashed out a problem to its conclusion, finds himself in a blind alley where he has inadvertently been inventing shapes of his own—shapes far less effective than those that nature can supply him with. He then back-pedals and tentatively sets off again.

So continues his development, and with each skirmish he strives to get ever a little closer to a fundamental truth. Please, therefore, bear with him in his desperate attempts to capture a small part of the visual wonder that is everywhere around us. It is perfectly understandable and completely excusable, on seeing isolated examples of various artists' work in a mixed exhibition, for one to jump on one's hat and stamp out muttering "It shouldn't be allowed!"; but don't shoot the artist—he's doing his best. Besides, perchance the poor devil may once have been a rational, decent, God-fearing engineer!

MAN AND HORSE

Growing Forms of Trees Used to Express Movement

Mr. Claughton was born in London in 1917. *He served an apprenticeship in the railway workshops of the London Transport Executive and was subsequently on the staffs of the Consolidated Pneumatic Tool Company and the Gloster Aircraft Company. As a sculptor he has carved an altarpiece for Lagos Cathedral, carried out commissions for several public and private bodies (including a recent stone relief on the new London Sessions House), and exhibited at various galleries.*

The photograph of the mathematical surface model is reproduced by courtesy of the Director of the Science Museum, South Kensington.

Letters to the Editor

ELECTROMAGNETIC PUMPS FOR LIQUID METALS

Sir, Mr. H. J. Northfield in his letter to you, published on September 7, page 292, estimates that a figure of 76 per cent. should be typical of the efficiency of an electromagnetic pump for liquid metal and he inquires why, in practice, an efficiency of 35 to 42 per cent. is more normal. He writes that electric motors having "solid" conductors have an efficiency of 89 to 90 per cent.; suggests that the reason for the low efficiency of pumps may be due to the fact that the "liquid molecules are 'free' and not 'bound' as those of a solid"; and continues by proposing a theory on these lines.

The reason for the lower efficiency of electromagnetic pumps is, in fact, not related to the greater freedom of movement of liquid molecules, since an electromagnetic force is exerted on the liquid metal in the same way as on a solid conductor. There are, however, a number of causes for this lower efficiency. First, the hydraulic loss is much higher than the friction loss in a motor and, because of this, it is necessary to employ large air-gaps in the magnetic circuit. Secondly, the larger air-gaps and the inability to mix magnetic and conductive materials means that the magnetising power required is greater, and, incidentally, this is responsible for the low power-factor of alternating-current pumps. Thirdly, the liquid has to be contained in robust metallic tubes and an appreciable current flows in the tube wall, giving rise to electrical losses. Lastly, the higher resistivity of liquid metals also contributes to lower the efficiency.

In practice, the relative magnitude of the different factors varies with the size of the pump and the liquid, so that the efficiency varies over a very wide range, from as little as 1 per cent. in small pumps of less than 1 gallon per minute, to as much as 50 per cent. in pumps of several thousand gallons per minute.

As an example, the distribution of losses in a 14 h.p. linear induction pump for sodium is:—

	Percentages
Hydraulic loss	5
Ohmic loss in liquid	28
Tube wall loss	14
Winding loss	14
Iron losses, etc.	4
Output power	35
Total input power	100
Efficiency	35

These figures are for maximum efficiency conditions, but are typical only of this particular size and type of pump.

Yours faithfully,
L. R. BLAKE.

The Research Laboratory,
The British Thomson-Houston Co., Ltd.,
Rugby.
September 28, 1956.

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SHEAR DEFLECTION IN BEAMS

SIR, I read with considerable interest the article on "Shear Deflection in Beams," by Dr. R. P. N. Jones, which appeared in your issue of October 5, page 428.

In regard to approximate solutions to this problem, I should like to draw the author's attention to some work in the field of naval architecture by Dr. J. Lockwood Taylor, and published in the *Transactions* of the North East Coast Institution of Engineers and Shipbuilders for 1924-25, under the title of "The Theory of Longitudinal Bending of Ships."

In this paper, Dr. Taylor produced a method whereby it is possible to calculate the modification to the theory of bending stresses brought about by shear stresses in the structure of a ship. He also shows how the shear deflection can be calculated. The work has become very widely

accepted among naval architects and Dr. Taylor's correction to vibration frequencies, based on this work, is almost universally adopted nowadays. I may say that I have applied the theory myself and found it extremely useful in problems where shear stresses could not be neglected.

Yours faithfully,

W. MUCKLE,
Reader in Naval Architecture.

King's College,
University of Durham,
Newcastle-upon-Tyne, 1.
October 8, 1956.

★ ★ ★

A FALSE RECORD?

SIR, Mr. Howells is surely in error in the view he expresses in his letter to you, published in your issue of October 5, page 424, regarding the suggestion that, in Mr. Campbell's recent attempt on the water speed record, the rules acted harshly on him.

It is convenient to consider the case of an aircraft of maximum airspeed v. If the wind velocity is u and the aircraft flies upwind, its measured ground speed is $v - u$ and, on returning downwind, $v + u$. The arithmetic mean of the ground speeds is v, i.e., the air speed in ideal conditions. The harmonic mean is obtained by dividing the total distance by the total time and is $v\left(1 - \frac{u^2}{v^2}\right)$, a function of the wind velocity. This speed is of interest to the pilot in preparing his flight plan but is irrelevant to an attempt to determine the speed of the aircraft in ideal conditions.

It is interesting to note the effect of a component of wind velocity w perpendicular to the track. The aircraft is yawed into the wind to make good the required track and achieves a ground speed of $v\left(1 - \frac{w^2}{v^2}\right)^{\frac{1}{2}}$ in both directions. The arithmetic mean of the measured ground speeds is, in general, less than the speed attainable in ideal conditions, but the harmonic mean is smaller still. The same conclusion is reached if v has different constant values in the two runs, or varies as a function of time.

Yours faithfully,

A. G. BURNE.

St. Julian's,
Sevenoaks,
Kent.
October 11, 1956.

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DROUGHTS

SIR, I have read the note "American Droughts" on page 454 (Weekly Survey last week) and, though I agree with the bulk of what you say, I beg to point out that I believe you to be wrong when you say "Britain has never experienced three dry years." In this part of the country such a sequence of dry years occurred in 1887-88-89, when the rainfalls were 32·5 in., 37·8 in. and 41·4 in. respectively, at a rain gauge for which the Meteorological Office calculate the standard average to be 45·7 in. I would point out, however, that the more important period is that of 18 or 19 months, covering two dry summers with a dry winter in between. Such cases occurred in 1933-34, 1947-48, and until July this year looked like occurring again, 1955-56.

Yours faithfully,

FRANK LAW,
Engineer.

The Fylde Water Board,
Sefton-street,
Blackpool.
October 15, 1956.

Weekly Survey

Cover Picture: *The heat treatment of steel castings is carried out, in this instance, in a fuel-fired furnace of the bogie-hearth type. The bogie is furnished with an insulated refractory hearth and is mounted on wheels running on rails. When loading is complete the bogie is pushed into the furnace and the vertical door lowered into position. Sand troughs along each side and in the front and rear of the bogie seal the furnace, thus preventing the escape of hot gases and the entry of air, while allowing cold air to circulate under the bogie.*

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Apprentices and Smaller Firms

The ninth London Regional Display of the Engineering Industries Association was held at the Royal Horticultural Hall, London, from October 10 to October 12. There were 152 stands covering industries as different as electronic components and spun-metal articles or woven-wire baskets and flame-cutting plant. Several of the firms exhibiting were prepared to undertake precision machining and prototype manufacture. Others offered expert knowledge in profile cutting (up to 8 in. thick plate) or the preparation of display drawings, while others were experienced as founders and factors. It was essentially a trade show for the manufacturer who wanted to know where work could be carried out or special items obtained.

With this range of activity to choose from, it is not unexpected that the group apprenticeship scheme, first started by the West London group two years ago, has flourished. In this group 40 firms now have 90 apprentices, and the scheme has been extended to operate in Kingston, Croydon, Slough, Birmingham, Dudley and Wolverhampton. Four types of trainee are catered for: craftsman, technician, student and graduate. The administration is carried out by Industrial Administration (R. & A.), Limited, of Hatfield, Hertfordshire. A supervisor maintains contact with the management, the instructors and each apprentice to make sure that he is receiving the maximum benefit from the individual programme that has been planned for him. Normally the boy receives the major part of his training at one works and is then transferred to others to widen his experience. Arrangements are made for him to attend part-time day and evening classes at the local technical college.

During the two years that the scheme has been working the improvement in the run of apprentices has been quite marked. Moreover, the general standard of training has improved as firms have taken a pride in their protégés. Many boys, who would have had little chance of an indentured apprenticeship apart from going away to one of the large companies, have benefited by the scheme, which offers far more than any single small firm could afford. Co-operative action of this type can go far towards finding the additional manpower so badly needed in engineering.

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Meeting Peak Loads in Electricity

How best to deal with peak loads, which may only last from one to five hours at a time and which may both rise and fall with great rapidity, is a permanent problem in the electricity supply industry. The problem has both its economic and technical sides, both of which were discussed by Mr. J. R. P. Smith in his paper "The Use of Internal Combustion Plant for Peak Loads on Electricity Supply Systems," which he read before the Diesel Engineers and Users Association on October 18. The first of these questions is complicated by a number of factors, which the author discussed in detail. His arguments may, however, be fairly summarised by saying that the fuel cost per kilowatt-hour for peak load plant is likely to be higher than the selling price. As a result, on the unit charge alone all the energy will be sold at a loss and the true value of any peak-load plant must therefore lie in the contribution it makes to the system at the time of the maximum demand. Moreover, the determination of the cost of running peak load plant is not easy, although it would appear that until it has been solved the economics of the problem cannot be more than approximate.

Technically, as Mr. Smith correctly points out, the most economical plant for covering peaks is that which can be run up and loaded quickly without wasteful use of fuel for warming up. This is not so simple as it sounds, as a good deal of the paper shows. The requirements are, however, satisfied by the inherent characteristics of the Diesel engine, against which must be placed its high input-cost rates and its limited unit capacity, the latter of which leads to high labour costs. Nevertheless, when the national plant position improved a few years ago the Central Electricity Authority decided to close down a number of uneconomic stations with capacities of less than 1,000 kW and to use some 50,000 kW of new Diesel plant which had originally been ordered to assist in dealing with load shedding, to make an economic, if small, contribution to the peak problem.

Owing to the small capacity of even the largest Diesel engine, compared with other prime movers which form a part of the system, it will seldom be necessary to operate the peak units at other than full load. Assuming full availability when required, the relationship between load factor, running hours and the annual amount generated will therefore be constant. Mr. Smith gives figures to show that if, in practice, such plant were run for about 800 hours per annum with up to 300 start-stop cycles, the results would be economically favourable. To schieve this end, however, the amount of skilled labour, whether engaged in operation or on maintenance, must be cut down to a minimum by some means or other and waste of other kinds, such as keeping unnecessary records, must be avoided. Starting-up procedure must also be investigated and care must be taken to select the right form of fuel and lubricating oil. It must further be stressed that rapid starting is an essential feature of the plant that is being considered. For that reason, where the running hours do not exceed 800 hours per annum, there is little financial advantage in using heavy fuels.

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Coal Gasification and Electricity

Progress is announced in the development of coal-gasification techniques with the decision of the National Coal Board to set up an Underground Gasification Executive as its contribution to the joint project with the Central Electricity Authority for constructing a pilot power station operating on this fuel. The new Executive will be responsible for producing and supplying the gas to the power station from where the C.E.A. will take over.

For some years a scientific advisory panel of the Ministry of Fuel and Power has been dealing with the underground gasification of coal and experimental work has gone on at two sites in the Midlands. More recently it was decided that the National Coal Board and the Central Electricity Authority should be jointly responsible for research and development with the assistance of the Gas Council and the Gas Boards. The largest single trial system so far has maintained a rate of gasification of about 20 tons a day—sufficient to generate up to 800 kW of electricity. A full report of these trials was published by the Ministry of Fuel and Power in March, 1956.

The new pilot station is likely to be at Newman Spinney in Derbyshire, where 500,000 tons of coal has already been gasified to produce electric power. The work will be carried out by contractors chosen by the N.C.B. It is likely that

several years will elapse before operations on a commercial scale will be possible. The target of gasified coal for electric power has now reached the stage of a pilot plant and a formal piece of administrative organisation to develop it. The stage is set for steady if hardly exhilarating progress.

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Gas Feels the Pinch

The gas industry earned a net surplus of £531,628 in the year ended March 31, 1956, compared with a surplus of £2,472,553 in the previous year. Sales of gas to industry increased by 4·3 per cent., and to commercial concerns by 5 per cent., but there was a decline of 2 per cent. in domestic sales. Eight area boards had surpluses and four had deficits. Thus the gas industry has suffered from the same difficulties as private industry in that turnover has increased but any benefit from it has been lost by rising costs. Gas totalling 2·6 million therms was sold during the year, representing a 1 per cent. increase on the year but the total expenditure per therm went up from 16·27*d.* to 17·64*d.* At a Press conference last week, Sir Harold Smith, chairman of the Gas Council, said he hoped the undertaking given in June not to increase gas prices before March, 1957, would be carried on beyond that date and he expects the industry to make a small surplus in the current financial year. It is notable that the income from the sale of gas appliances fell severely during the year owing to hire-purchase restrictions and increased purchase tax. Gas and coke appliances sold on hire purchase during the year were reduced by nearly 38 per cent.

Progress has been made with the use of oil as an alternative to coal. The gasification of oil now takes place at 8 plants and 20 more are in course of erection, and these are expected to represent an eventual saving of 850,000 tons of coal a year. The largest plant being built is the one on the Isle of Grain which is to use the Segas process developed by the South-Eastern Gas Board in collaboration with the British Petroleum Company Limited. Further developments on the oil side have been the arrangements made recently with the large oil companies for the supply of refinery gas from Shellhaven and Fawley. The Gas Council is now half way through its five-year survey programme for natural gas but, so far, it has not been found in commercial quantities.

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European Free-Trade Area

The public debate on Britain's participation in an agreement with the countries of western Europe establishing a free-trade area is gathering momentum. The Federation of British Industries have already discussed the implications for their members of the proposals for a Common Market and Customs Union. A special meeting of their Grand Council has been summoned for October 31, when representatives will resume their discussions and report to the Government. Until then meetings will be held with trade associations and companies to determine what attitude British industry is to take.

So much has happened in the past 25 years that it is hard to recall that before 1931 we were a free-trading nation. Industry has become so accustomed to tariffs and quotas at home that the change, however gradual, will hurt hard in places. That there will be controversy in industry cannot be doubted. The clash in the correspondence columns of *The Times* of two leading members of the textile industry, Mr. Cyril Lord and Sir Kenneth Lee, suggests that it will be fierce and bitter. Sir Kenneth writes, "I see danger if we do not join the European market. Lancashire is suffering from old age. Its competitors are working with automatic machinery running long hours. Lancashire's factories in the main work one shift with oldish machinery. High protection can do anything for a short time, but discrimination against a Europe-wide progressive industry will never enable Lancashire to sell its goods abroad. . . ." Mr. Lord replies, "Sir Kenneth Lee should let the younger generation . . . express their views without supporting an impossible legacy which European free trade would give us. . . . No export business can be built except on a solid home-trade foundation. The idea of European free trade is again another example of tackling something at the academic and the theoretical level instead of the functional. . . ."

The engineering industries are in many cases better placed, and can hope to secure important business across the channel. A free-trade area is likely to lead to increased competition but also to more equal wage levels and to movement of capital from "surplus" to "deficit" countries. A recent O.E.E.C. report on the United Kingdom concludes that greater foreign competition at home is necessary as "an important means of combating internal price inflation, as well as providing a basis for the necessary expansion of the United Kingdom's own exports." The trade unions are now considering their attitude. Some of their leaders believe that Britain cannot afford to stay out of a free-trade area, but there are fears that wages and conditions would be forced down to the lowest level in the area. Elsewhere also, among scrap-metal merchants, in the motor industry, in the textile machinery industry and others, opinions are divided. But to quote Sir Kenneth Lee again, "integration with the European market must hurt somebody. The Chancellor's problem is to secure the general interest which, I am sure, he has fully in mind."

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Engineering in Czechoslovakia

Some measure of the progress being made by the engineering industry in Czechoslovakia may be obtained from the fact that the second exhibition devoted to the industry in that country has been held only twelve months after the first, and that it is intended that similar exhibitions shall take place annually. In selecting Brno, the ancient capital of Moravia, as the site for both these events, the organisers, the Chamber of Commerce of Czechoslovakia, appear to have been influenced not only by that consideration but also by the town's importance to textile manufacturing and to the location there of many firms connected with heavy engineering.

This year's exhibition was arranged in five main sections, each under the management of one of the Foreign Trade Corporations of the State, and covering products ranging from fine precision instruments to heavy machinery. From the number and range of machine tools shown by Strojexport, the conclusion could well be drawn that Czechoslovakia has become largely self-supporting in this direction. Among the exhibits of particular interest were two heavy-duty radial drills; one, a stationary machine, capable of drilling holes of up to 5 in. in diameter and 18½ in. in depth in grey cast iron, and the other, a portable machine, specially designed for erection work on the site, which can produce holes of up to 2 in. in diameter and of up to 14 in. in depth. A Skoda excavator, mounted on crawler tracks 4 ft. 3 in. wide, was also at the exhibition and is illustrated on this page. The machine is of fabricated construction and can handle approximately 90 cub. ft. of material at each stroke. It is understood that another Skoda excavator of the same type, but with twice the capacity, is in the planning stage. Other exhibits were the Nama automatic bottling unit, which can handle bottles of up to 3½ in. in diameter and 10½ in. in height at the rate of 6,000 an hour, and a twelve-roller cane-crushing mill.

Also worthy of mention was the transportable power plant of 1,500 kW capacity, complete with boilers, coal-handling plant, slag-removing equipment, water-purification unit, turbine and generator. The whole assembly covers an area of 100 ft. by 50 ft. and has been constructed for shipment to China. It has been made in sections, each of less than 5 metric tons in weight and within the size limits prescribed by international railway regulations. The motor section, which attracted much attention, contained a full range of Skoda and Tatra passenger and commercial vehicles, and various types of Jawa motor-cycles. Among the exhibits was the Tatra III-R lorry, powered by a 180 h.p. twelve-cylinder air-cooled Diesel engine. There was also a wide range of agricultural machinery, including combines for dealing with flax and sugar beet.

The exhibition, which began on September 8, was due to end on September 30, but was extended to October 7, and it was estimated that, by the closing date, more than two million persons would have attended.

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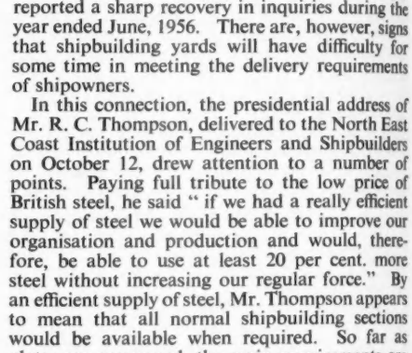
Standardised Ships Again

All indications point to a high level of activity in shipbuilding yards. Freight rates are at a peak, official industrial production indices indicate a renewed burst of activity since last year and, last week, the Ship Mortgage Finance Company (which makes medium-term loans secured by first mortgages on completed ships) reported a sharp recovery in inquiries during the year ended June, 1956. There are, however, signs that shipbuilding yards will have difficulty for some time in meeting the delivery requirements of shipowners.

In this connection, the presidential address of Mr. R. C. Thompson, delivered to the North East Coast Institution of Engineers and Shipbuilders on October 12, drew attention to a number of points. Paying full tribute to the low price of British steel, he said "if we had a really efficient supply of steel we would be able to improve our organisation and production and would, therefore, be able to use at least 20 per cent. more steel without increasing our regular force." By an efficient supply of steel, Mr. Thompson appears to mean that all normal shipbuilding sections would be available when required. So far as plates are concerned, the main requirements are for complete consignments free from defects and in sufficient quantities. He pointed out that, if deliveries of steel do not arrive in complete bulkhead units, all-welded bulkheads are subject to indefinite delays. This is an outstanding problem for builders of tanker tonnage at the present



Skoda fabricated excavator.

time. He said that it would be an enormous advantage, in the case of prefabricated welded work, if plates could be supplied commercially flat, with straight edges and of rectangular shape, so that they can go straight to the prefabrication shed without edge preparation. Certain consignments have been received from continental suppliers in this condition, but not from home steel makers. Mr. Thompson also put in a plea for shot blasting by steel makers instead of by shipbuilders, since the removal of mill scale is a growing requirement, at present mainly by tanker owners but possibly, later, by owners of cargo vessels as well. Such thoughts, inevitably led him, when discussing the price of ships, to call for the encouragement of standard-type ships, both for hulls and for machinery. Very significant economies could be achieved, he thought, in all types of ships, by a degree of standardisation and the case was particularly strong in regard to tankers. Since tankers are going to comprise a very significant proportion of new tonnage launched in the next few years, the point clearly assumes growing importance.

* * *

For Record and Research

The 10th Congress of the International Scientific Film Association was held in Vienna from September 23 to 29, and attracted a record attendance of 150 delegates and observers from 25 countries. As in previous years, in addition to meetings of the general assembly, there were section meetings devoted to films in medicine and surgery, veterinary work, research, industry, and the popularisation of science. Those films shown to the technical and industrial section dealt with such problems as work study, health, safety, and welfare, and industrial research. There were some excellent film records, for example, of the use of X-rays in metallurgical research, stroboscopy in the study of fast moving working parts, and the application of ultrasonics to various branches of industrial research. But there was little new either in the industrial techniques or in the methods of recording them on film.

Perhaps the highlight was a ten-minute Soviet film showing the continuous casting of a 9 in. diameter steel billet. The technique is familiar and there have been other film records of it, but the novelty of the Soviet contribution was in the scale of operation, the size of the billet (about twice that of the one seen in "Continuous Casting in Barrow," the United Steel film), and the design of the launder.

The quality of the industrial films shown at the Congress, the too frequent failure to produce for a specific, well-defined audience, and the abuse of musical background all attracted unfavourable comment. It was emphasised, moreover, that all this showed the need for a much greater international exchange of information about industrial films. Nevertheless, despite the paucity of really new material many of the film techniques seen at the Congress may have important industrial applications—X-ray cinematography, for example; the use of infra-red lighting to record processes taking place in darkness; the possible application of endoscopy for recording in enclosed apparatus; and the further development of high-speed and stroboscopic filming.

* * *

Italian Industry and the Press

In Britain we are used to the idea that the Press obtains a greater part of its income from advertisements than from sales. The charge arising from this situation, that advertisers were able to influence editorial policy, was examined by the Royal Commission on the Press and declared unfounded. In Italy the position is very different. For one thing, the mass-circulation newspaper does not exist. There are 113 daily papers embracing a circulation of five million—about the daily sales of the *Daily Mirror*. It is not surprising therefore that few dailies attract enough advertising to bring in a reasonable income.

The gap between income and costs is filled by subsidies from political parties, wealthy individuals or industry. The big federation of Italian industry—Confindustria—controls some twelve provincial papers and the influential *Il Giornale d'Italia* of Rome. It also runs the three financial journals *Il Sole*, 24 *Ore*, and *Il Globo*. Many industrial concerns are in the newspaper business on their own, apart from sharing in the Confindustria interest. Italcementi, which is a key organisation in the cement industry, owns various newspapers including two Milan evening papers. Eridania, the sugar company, is another firm with interests in various papers including *Il Tempo* of Rome.

The system produces some peculiarly Italian situations. For example, *Il Matino*, a Neopolitan daily, is owned by the Bank of Naples, which is controlled by the Government. The second biggest daily, *La Stampa* of Turin, is partly owned by Fiat. *Il Corriere della Sera*, the paper with the largest circulation, is probably the nearest approach to an independent newspaper. On the whole it is true to say that the Press in Italy is not particularly influential, and is not held in very high esteem. Mass circulations have many drawbacks but at least they ensure sufficient income to give their editors freedom of comment. It is a point the critics of the Press often overlook.

* * *

Critical Role for Constructional Engineering

In so far as official figures represent accurately the trend of economic events, they show unmistakably that industrial building work is at present playing the major role in sustaining general industrial activity. Capital expenditure returns in the first half of this year show that building work was running at an index number of 176 (the average of 1954 being 100) compared with 120 in the first half of 1955. This was a much bigger increase than was recorded by the other industrial groups making capital expenditure returns. Even so, the index was one point lower in the first half of 1956 than in the second half of 1955.

Figures released last week by the Board of Trade for capital expenditure in the second quarter of 1956 show the gradual slowing down in the rate of expansion. In manufacturing industry, the second quarter's expenditure was 26 per cent. higher than in the same quarter of 1955, an increase which compares with a 27 per cent. rise when the first quarter of this year is compared with the corresponding period of last year. In the "other industries" group the increase for the second quarter was only 5 per cent. on the year compared with a jump of 44 per cent. for the first quarter. Forecasts of expenditure between 1956 and 1957, which were given by companies earlier this year, have not been seriously modified by information coming more recently from other companies. Companies in manufacturing industry seem to have reduced their expected outlay on capital investment between this year and next by only 1 per cent. An important exception to this, however, is the shipping industry which expects to spend an extra 5 per cent.

The number of building schemes for which approval has been obtained continues to decline. Between the first quarter of 1955 and the third quarter of 1956 the number of approvals has dropped from 934 to 570, a decline of nearly 40 per cent. On the other hand, the area approved for new building in the third quarter (at 20·6 million square feet) is much higher than the second quarter and almost back to the level of the first quarter. Since this includes an expansion scheme for the Margam steel works in South Wales and a new oil refinery near Southampton, the number of schemes approved may be a more reliable index of the trend than the area. If this is so, and making such allowances as may be necessary for the limited coverage of the official figures, the present high level of capital investment seems to be dependent upon a branch of industrial activity which is beginning to lose a good deal of its impetus.

* * *

Steel Shifts to Capital Equipment

Net home deliveries of finished steel in the first eight months of 1956 are provisionally estimated to have been just over 270,000 tons—which was 8 per cent. more than in the same period of last year. This increase was accounted for by larger deliveries to coal mines, railways, rolling stock, shipbuilding and general and constructional engineering. There was a slight decline in deliveries to stock holding merchants (which may yet be significant owing to the strong stock position of many steel-using companies). There was also a larger drop in steel for motors, cycles and aircraft.

Imports of steel over the same period show the same pattern in an even more marked degree. In the first eight months of this year imports of steel were noticeably higher than in the same months of 1955, although the rate of importation has dropped sharply over the summer and is now well below the level at the same time in 1955. Imports of plate and sectional steel have increased this year while imports of sheet and tinplate have fallen well below last year's level. So far as tinplate is concerned, the drop is largely accounted for by the new capacity coming into operation in Wales. The drop in sheet-steel imports reflects the current difficulties of the motor-car industry. While the import trade in sheet steel has tailed off, trade remains brisk in pig iron, semi-finished steel and in such finished steel products as bars and rods, sections and plates. It is becoming apparent that the recession in the motor-car industry, which was encouraged in a sense to force the industry to export more cars, has had a more immediate salutary effect on the external trade position by reducing the demand for foreign sheet steel.

* * *

The Humanity of Natural Rubber

At the conference on "Rubber in Engineering" held in London recently, and summarised elsewhere in this issue, some of the speakers found a marked affinity between the behaviour of natural rubber and that of a human being. In molecular structure, for example, rubber is strongly akin to animal muscle fibre and, therefore, responds to conditioning by gentle exercise. It can "remember" how it was processed, and if, for example, a component is moulded from a blank built up from extruded coil, it may under loading tend to revert to that form. For this reason, it is generally preferable to use an injection moulding process for engineering components required to stand up to vibratory loads, often in the presence of oil.

To another speaker, rubber appeared to belong to the feminine sex; its success in agricultural machinery applications he attributed to what he referred to as its "unpredictability," but which we should prefer to describe as its greater readiness to adapt itself to unconventional situations.

* * *

Synthetic Rubber Imports

It was announced at the end of September that the Government has authorised an import programme of 80,000 tons of synthetic rubber in 1957. This comprises 20,000 tons of special-purpose synthetic rubber, the same quantity as

in the previous year, and 60,000 tons of general-purpose GR-S rubber, which compares with 50,000 tons in 1956.

There has been a very marked rise in U.K. imports of synthetic rubber in recent years. Up to 1953 consumption did not exceed 5,000 tons a year, but in 1955 imports rose to over 20,000 tons and in the first half of 1956 imports were at the rate of 78,000 tons per annum. These figures compare with a new supply of natural rubber to the U.K. of 270,000 tons in 1955.

Imports of synthetic rubber in 1957 will be supplemented by production from the first two factories erected in this country, namely those of Imperial Chemical Industries at Wilton and of Monsanto Chemicals at Newport. The first of these has been designed to produce about 10,000 tons of butadiene-based materials a year, while the second will have an annual capacity of about 4,000 tons. Both these plants will produce special-purpose reinforcing resins, the I.C.I. plant producing three different types, namely butadiene-styrene for which the main use is in shoe-soling materials; butadiene-methacrylate for which the main application will be in emulsion paints; and butadiene-acrylonitrile for oil-resistant rubbers. Monsanto Chemicals will produce in the first instance butadiene-styrene co-polymers and are expected later to produce butadiene-acrylonitrile materials as well.

In addition to the above, the 2,000 tons per annum experimental plant of the Dunlop Rubber Company at Fort Dunlop is expected to be in full operation before the end of 1956, but it is likely to be about two years before any large contribution is made from home sources to the supply of general-purpose synthetic rubber, when the 50,000 tons per annum plant of the International Synthetic Rubber Company is expected to be completed.

The growing use of synthetic rubber both in this country and the United States, where natural rubber now accounts for only about 40 per cent. of total rubber consumption, is provoking strong reaction from producers of natural rubber. The Malayan producers have appointed a technical committee to study the question of increasing production and reducing costs, and it is expected that the Malayan Minister for Commerce and Industry may put forward a request that U.S. dollars earned by Malayan natural rubber should be paid into a separate account in the Commonwealth Pool and not be available for the purchase of synthetic rubber. The view of the British Government, however, is that adequate supplies of synthetic rubber are essential if British exports of rubber manufactures, which amounted to over £40 million in the first half of this year, are to remain competitive in world markets.

* * *

Synthetic Fibre for Northern Ireland

Chemstrand Limited, the subsidiary in this country of the Chemstrand Corporation in the United States, have announced that they are constructing a plant to make Acrilan—one of the newer synthetic fibres derived from acrylonitrile, which is petroleum-based—near Coleraine in Northern Ireland. The Chemstrand Corporation has a plant in Alabama which makes nylon and Acrilan. Until the new plant is in production, Chemstrand Limited will continue to sell Acrilan from its warehouse in the north of England. It is expected that the first goods to be made from Acrilan will be available in the British home market within the next few months. Presumably, the parent American company is sufficiently confident in the claims made for it to empark on this £3½ million scheme despite the growing competition among synthetic fibres in the textile market.

The new plant, which is being designed and constructed by Costain-John Brown Limited, of London, will employ about 400 people and is expected to take two years to build. In its first stage the unit is planned to produce 10 million lb. of Acrilan fibre a year, which is about half the capacity of the I.C.I. Terylene plant at Wilton. This is a fairly ambitious start; it will be recalled that the Terylene plant took some years to build up beyond 2 million lb. of fibre a year.

The American synthetic fibre industry developed the Acrilan fibres during the war, and in spite of commercial teething troubles they established early a reputation for resistance to fading and chemicals, although at one time difficulties were encountered in dyeing. More recently Germany has speeded up the development of polyacrylonitrile fibres, as its petroleum industry has recovered, and in due course competition may be expected from this source. Meanwhile there are reports that the United Kingdom hosiery industry has experimented successfully with acrylonitrile fibres and that, blended with wool, they have compared favourably with cashmere and other rare growths of wool. It remains to be seen to what extent this new American investment in Northern Ireland has stolen a march on the British synthetic fibre manufacturers who have been developing new products in the acrylic field.

* * *

Chairman's Corner

Expansion and Exports

A lively introduction to engineering exports, which are discussed in many of the chairmen's reports published last week, is provided by the board of directors of the Addo Group of Malmö, Sweden, who manufacture office machinery. "The Sterling market for bookkeeping machines is looked upon as very interesting by the management . . . further export markets were opened. Among these, Japan should be mentioned in particular. The upward trend in exports seems to continue during the present year. . . . The United States market has secured its position as the greatest market of the Addo Group. . ." Nine of the 18 companies whose reports are available mention increasing export sales, or efforts to increase them. It is perhaps too early to comment on the effect of the Government's policy designed to divert production from the home to overseas markets. Nevertheless, some of the chairmen's remarks suggest that it is having an effect, even if somewhat brutal.

A. C. Cossor, Limited, who were forced to dismiss 1,200 workers during the year ending March 31, report an increase in the value of exports from £1·6 million the previous year to £2·1 million. The cancellation of £6 million worth of defence contracts hit the company hard, as did the hire-purchase restrictions on the sale of radio and television apparatus. The remarks of their chairman, the Marquess of Exeter, are most apposite: "Here you see, in our own affairs, the Government's financial measures producing effects considered desirable from the national point of view. Reduction in spending by the public, reduction in Government expenditure, re-deployment of labour, increased exports, lower prices—all these have resulted. But at what cost to us!" The half-yearly report of the Ford Motor Company reveals sharply reduced profit margins—7½ per cent. compared with 14·6 per cent. in the corresponding period a year ago—but also a strengthening of the company's competitive position at home and abroad. The number of vehicles sold has increased at a time when the output of the industry as a whole has contracted further. Mr. D. G. N. Lloyd-Lowles, chairman of the Tap and Die Corporation, Limited, reports a splendid export performance: "exports represent 25 per cent. of our sales and are 15 per cent. higher than last year. This may be taken as some indication that our prices are still competitive, although any increase due to rising costs might easily have had an adverse effect." Mr. Lloyd-Lowles mentions that special efforts are being made to increase exports still further, "although it is less profitable," to help the country's export drive.

Other companies which mention an increased export drive include Horseley Bridge and Thomas Piggott, Limited, who report they have secured many large overseas contracts for constructional engineering schemes "against world competition"; the Rank Organisation Limited, whose exports of optical precision instruments and cinema projection equipment (Rank Precision Industries, Limited) are the largest in the United Kingdom; Midland Industries, Limited, who make steam traps, valves and agricultural implements and Ransome and Marles Bearing Company, Limited, "although difficulties associated with import licences and intense competition remain." On this evidence, therefore, British engineering's export drive is being well maintained and used as a basis for expansion, as indeed it must if we are to prosper.

* * *

Expansion Through New Products

There has been evidence during the past year or so of an all-out attempt on the part of many old-established engineering companies to find new products on which to base further expansion. In part this is due to the wish to keep ahead technically, and many of the products are being made under licence from the most-advanced overseas concerns. Another reason is the reluctance to be wholly dependent on one industry, particularly if it is subject to fluctuations in output—as at present the motor industry, or in the past the shipbuilding industry—or if it is a nationalised industry. This can be readily understood, since the latter are at the mercy of the Government's financial policy and generally the first to feel the effects of an economy drive. The same attitude is now widespread among those companies who supply components to the manufacturers of household appliances and private cars and among those manufacturers themselves.

The Cossor Company report that they are "giving particular attention to extending two fields of activity which seem to offer both scope for expansion and less risk of interference": electric instruments and telecommunication equipment. In the latter field the Marquess of Exeter states that a new subsidiary company has been set up, with a strong development team. The Rank Organisation are energetically pursuing a policy of expansion in the precision engineering field, and, Mr. J. Arthur Rank reports, his company have extended their agreement with Bell and Howell of Chicago for a further 20 years. They have also concluded an agreement with the Haloid Company of Rochester, U.S.A., for the development of the xerography photographic printing process. Serck Radiators, Limited, whose main customers are motor manufacturers, have acquired Audley Engineering Company, Limited, manufacturers of valves for a wide range of industries. Joseph Lucas are now making domestic and industrial oil burners and paraffin stoves. Many other companies have taken similar steps in recent months.

Metal Industries, Limited, on the other hand, found their incursion into the automation field, through their subsidiary Sentinel (Shrewsbury), Limited (the development of the Renault system of mechanical unit heads) too heavy a drain on their financial resources and sold the company to Rolls-Royce Limited. There is always a risk attached to departures into new fields, and the note of caution sounded by Mr. Lloyd-Lowles, chairman of the Tap and Die Corporation, is relevant. Mentioning his company's desire to expand "by the acquisition of a kindred business" and his dislike of having money lying idle, he said that nothing suitable had presented itself and that the Board felt it would be "wiser to wait for some really attractive opportunity to invest the money than to rush into something which we were not absolutely happy about."

Fig. 1 "Mercury" is a very fast computer which solves a wide range of technical and scientific problems. It is made up of three main sections and has four storage units in separate cubicles.

COMPUTERS "OFF THE PEG"

PRODUCTION LINES NOW IN OPERATION

An idea of the extent to which the use of computers has grown may be gained from the fact that Ferranti Limited have installed a production line for their manufacture at West Gorton, Manchester, 12. This factory was taken over by the firm in March and has been modified for the production of computers and also of transformers; the former division is now approaching full production, but the transformer section has not yet moved in. At a recent visit to the factory by the technical Press, there were 11 computers at various stages of construction, and orders in hand were for 34. The floor area of the computer section amounts to 150,000 sq. ft.

Two basic types are being made at present, the Mercury and the Pegasus. The Mercury, a model of which is illustrated in Fig. 1, is a large and very fast machine, capable of carrying out almost all calculations. Arithmetical operations take on an average 180 micro seconds to perform. Numbers are represented in "floating point" form which means that overflow of a register cannot occur, and a very large storage capacity is included. Pegasus is a smaller machine, not so fast in operation but having the advantage of a simpler programming procedure, and is capable of performing a very large range of operations. It is being manufactured under patent licence from the National Research Development Council, and the model installed at the computer centre in London is shown in Fig. 2.

That section of the factory at West Gorton which is devoted to computer production is divided into two main parts: the machine shop and fitting section; and the wiring and assembly section. The latter is shown in Fig. 3. From a constructional point of view, one of the main differences between the two computers is that Mercury is mainly based on fairly large chassis units, while Pegasus employs a large number of small plug-board units which can be withdrawn and replaced in a matter of seconds. The chassis and boards are made in the machine shop and the components assembled on them on the production lines. A considerable amount of pre-formed wiring is incorporated. Also made in the machine shop are the tape readers, tape punchers and the storage drums. The enormous number of components involved in each computer, calls for a relatively large progressing department.

The plug boards are made up from laminated resin sheet, at one end of which the plug contacts are mounted, while the other is formed into a handle. Components are mounted on both sides. Inspection and testing are carried out at 13 stages during assembly, and the complete unit is tested in a rig before being mounted in the computer. The fact that large numbers of a few types are required to form the complete computer section allows flow production to be easily applied. A similar condition exists with the chassis used for Mercury. In Fig. 3, the three sections which go to make up the Mercury equipment can be seen in the left foreground; a Pegasus unit is on the right. Interconnecting wiring is carried out by numbers; each connection point is uniquely numbered and the route of each wire is marked with the same number whenever it passes through a guide board until it reaches the final position. In this way, the wireman does not have to follow any complicated diagram. Each type of plug board of Pegasus is identified by coloured discs and its position in the panel marked in the same way not only to ensure that the right type is used but also that it is inserted the right way up.

MAGNETIC DRUM STORAGE

The backing store for Pegasus is made up of a drum mounted horizontally and coated with magnetic oxide. Spaced round the outer casing are the recording heads which are built up from a ferrite core embedded in insulating material. The terminal plug is moulded in bench moulding machines, complete with the connecting pins. One of the essentials of a drum store is that it shall revolve concentrically and this involves machining on a centre lathe with an accuracy of $\pm$ 0·0001 in. To ensure that the recording heads are spaced at exactly the correct distance from the drum surface, a hole is left in the head through which air can be passed allowing the distance to be checked by a standard air-pressure measuring technique. The Pegasus drum is rotated by an external electric motor at a speed of 3,720 r.p.m. It has a capacity of 5,120 "words" (i.e., numbers or pairs of orders) of which 1,024 words are on a separate section devoted to input routine and checking programmes. The word length is 39 binary digits, which are equivalent to 11 decimal digits.

For Mercury, the backing store consists of four magnetic drums, each mounted in a single unit (extreme right, Fig. 1). In this case the drums are mounted vertically and the driving motor is internal. The four drums give a total capacity of over 16,000 words and, being independent, offer the additional advantage that the breakdown of one of them does not prevent the computer from continuing to work.

The computing store used in Mercury depends on very small magnetic cores. These are arranged in squares of 32 by 32 mounted on insulating boards. Between the cores run vertical and horizontal wires, which are used to identify the core specified, and diagonal wires which are used to read the core content. Nickel delay-lines, each holding one word and mounted on the

Fig. 2 "Pegasus" is a general-purpose machine for most industrial work. The programming operation is much simpler than for Mercury but the machine is not quite so fast and has a smaller storage.

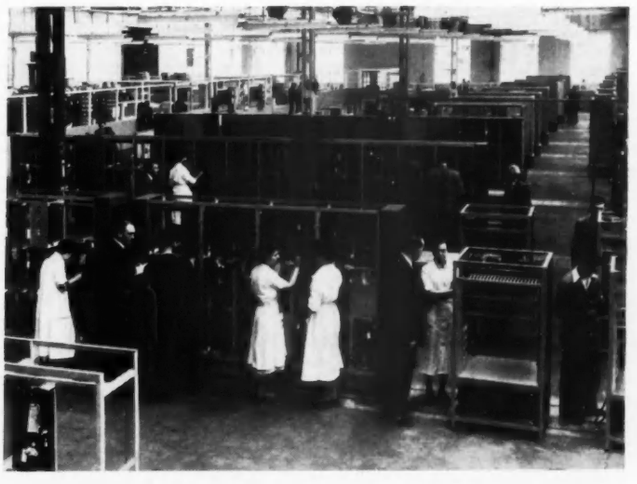


Fig. 3 In the assembly section, panels for Mercury are in the left foreground, and for Pegasus on the right. Other Pegasus units nearing completion are in the background.

standard plug boards, are used in Pegasus for this purpose.

The tape readers used for supplying information to the machine are capable of reading either 200 or 400 characters per second according to the type. A 5 hole tape is used. On the output side the puncher can produce tape at a maximum of 50 characters per second. This discrepancy in speed is not so unfortunate as might appear, as more information has to be fed in than results are expected out. The output punched tape can be used to give printed numbers on a standard electro-typewriter. Control of the reader is such that it can be stopped within the space of a single character. Two readers are employed on Pegasus with changeover switching arranged by the programme.

Research laboratories occupy quite a large part of the floor space, and work is being carried out on many facets of computer design. Those at West Gorton work in conjunction with the ones at Bracknell and the existence of two establishments offers certain advantages. One is that staff can be drawn from two separate areas, and the other is that a difference in outlook on a problem can often be of great service in solving it. The former, however, is probably the main reason for not having all the research facilities at one place.

VERY HIGH SPEED READER

One item which has been developed is a cassette for holding punched tape so as to ensure freedom from damage by careless handling and also giving easy feed to the reader. Particularly for the very high-speed computers (Mercury is from 8 to 40 times as fast as the first Manchester installation) there is being developed a high-speed reader that can handle 1,500 characters per second and can still stop before reaching a second character. To safeguard against breakage of tape at these speeds (about 1,000 ft. in 75 seconds) the tape is hung in free loops on both sides of the reader. A system of photo-electric cells governing the speed of winding ensures that the loops are kept approximately constant. The tape can be rewound in 30 seconds.

The plug boards of the Pegasus type are being improved by substituting transistors for some of the valves and printed circuits for the wiring. A " ballot " device, operated by two extremely small transformers, is being investigated. The device is intended to select whether a pulse is accepted in a circuit by summing the " orders " for and against. In connection with this work, miniature " clip-on " ammeters have been developed for circuit testing. The smallest transformer employed is a toroid, about 1 mm. in diameter, on which are 134 turns of wire in several separate windings.

LOSS OF DATA ON SWITCH-OFF

Development is also being carried out on a 25 millisecond delay line of piano wire, capable of holding a large number of words. Nickel wires at one end apply a torque to the piano wire when they are energised, and this is detected by a similar arrangement at the other end. Delay line storage is quicker to get at than with a drum, and also considerably smaller. At present, however, it is more expensive to produce. There is also the disadvantage that the information stored is lost when the supply is switched off.

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EXPLOSIVE PUNCH FOR HOLES IN RAILS

Quicker Electrical Bonding

A new method of rail bonding to ensure electrical continuity has been introduced by the Velocity Power Tool Company, 201 N. Braddock-avenue, Pittsburgh, 8, Pennsylvania and was used by the W. V. Pangborne Company Inc., on the recently completed extension of the Market-street subway in Philadelphia. By employing it, it is claimed, drilling is no longer required, the punched hole requires no reaming (so that the bonding plug can be at once inserted) and the operating time is reduced from about 45 to 15 min. per bond.

The new tool, which weighs 61 lb. and can punch holes up to 1¼ in. in diameter through 90 to 115 lb. rails, is operated by a cartridge of smokeless gunpowder which is inserted behind a piston and is fired by a special hammer. The punch is thus driven through the rail and along with the slug is retrieved in a receiving die. Two workmen are normally required for the operation of the equipment, one of whom retracts the piston and inserts the punch and cartridge, while the other clamps the tool in the correct position on the rail by tightening the screw of the receiving die. The appearance of the new punch will be clear from the illustration below.

★ ★ ★

PREVENTION OF ACID CONDENSATION IN OIL-FIRED BOILERS

The problem of low-temperature corrosion in the economisers and air-heaters of boiler plants has been given a good deal of attention of late years and while the basic cause of the corrosion is recognised, the precise mechanism of the reactions which take place are still under discussion.

Several means of eliminating this attack have been suggested at various times but none has proved entirely satisfactory and, for this reason, a method put forward by Mr. L. K. Rendle and Mr. R. D. Wilsdon, who are attached to the Research Station, Sunbury-on-Thames, Middlesex, of the British Petroleum Company, Limited, will be of interest to many engineers. These two authors have described their work in a paper, entitled " The Prevention of Acid Condensation in Oil-Fired Boilers," contained in the September issue of the *Journal* of the Institute of Fuel. They point out in their introduction that, briefly, the bulk of the sulphur compounds in the fuel is oxidised to SO_2 on combustion but that a small proportion is further oxidised to SO_3. Although the SO_3 is present in the flue gases in very low concentrations, amounting to from 0·002 to 0·005 per cent. by volume in the dry flue gases, it causes a rise in the water dew-point from about 40 deg.–45 deg. C., to about 140 deg. C.

The authors go on to say that to prevent condensation and subsequent corrosion on the economiser and air-heater surfaces, it has been the practice to maintain these at temperatures well above the acid dew-point of the flue gases, thus protecting the heat-exchange surfaces at the expense of a considerable reduction in the overall thermal efficiency. The work at Sunbury began as a laboratory investigation into the effect that the sulphur content of the fuel oils had on the dew-points of flue gases, but was continued as a search for an economic method of removing the SO_3 in a harmless form.

After trying a number of materials, including zinc dust, dolomite, magnesium oxide, magnesium soap and zinc and magnesium naphthenates, it was found that the addition of ammonia to the combustion gases at a temperature of about 300 deg. C. and at a concentration of 0·06 per cent. weight of the fuel was the most effective and cheapest method of eliminating the acid dew-point and of reducing the corrosion of exposed steel surfaces to a negligible level. It is emphasised that the equipment required is simple and needs little or no maintenance, and that the gas is cheap, readily available in large quantities and is of uniform quality. It is felt also that the recovery of ammonium sulphate from the soot and ash, for sale as a fertiliser, might be practicable.

The authors point out, in conclusion, that while their process has been applied to oil-fired equipment, its adaptation to solid-fuel burning installations should present few problems. Power stations and industrial boilers and cement, brick and pottery kilns, whether fired by oil or solid fuel, have their specific corrosion problems associated with acid condensation. A widespread application of the principles of the ammonia-injection process might provide a cure for these difficulties and at the same time increase plant efficiencies.

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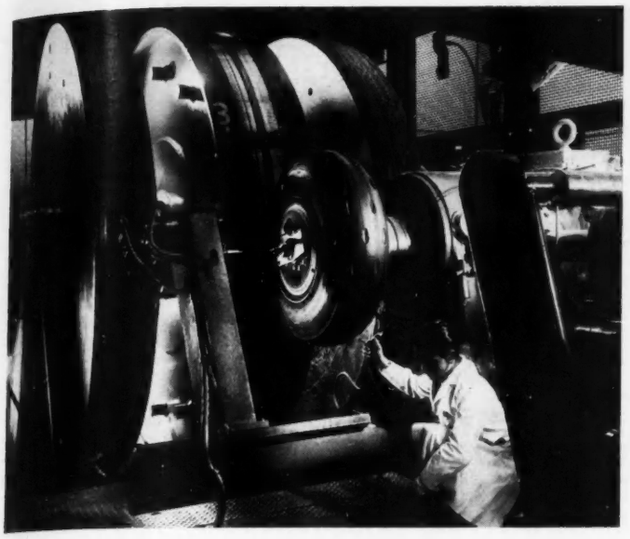
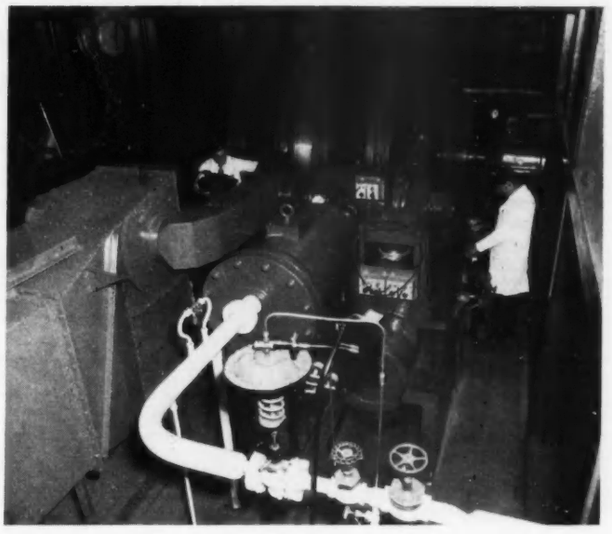
HEAT-RESISTANT RUBBER

Hypalon is the most recent addition to the range of synthetic rubbers produced by E. I. Du Pont de Nemours and marketed in this country by Durham Raw Materials, Limited, 1-4 Great Tower-street, London, E.C.3. The material is made from polyethylene, chlorine and sulphur dioxide, and has some properties not possessed by other elastomers.

The heat resistance is good, and conveyor belts carrying materials at 300 to 500 deg. F. last twice as long as when made in other synthetics. It is particularly resistant to attack by ozone (unaffected by 6 parts in 100) and other oxidants, and to weathering generally; white coatings on boats have withstood three years service without deterioration. Hypalon is very resistant to abrasion and to attack by most chemicals; electrical properties are also good, the di-electric strength being from 400 to 600 volts per mil. It can be compounded to give different colours and can be used as solid or as a coating for other materials, as for example, rubber weather strips.

An explosive punch which greatly reduces the time taken to form holes for rail bonds.





Dunlop's dynamometer for testing wheel assemblies under normal and emergency braking loads at landing speeds up to 200 m.p.h. has a maximum energy capacity of 66 million ft.-lb.

DYNAMOMETER FOR AIRCRAFT WHEEL ASSEMBLIES

LANDING LOAD APPLIED ON TYRE, WHEEL AND BRAKE

As aircraft speeds rise, loading conditions upon undercarriage tyres, wheels, and brakes are becoming increasingly severe, both on account of the higher landing speeds that are becoming accepted practice, and because of the necessity for keeping landing gear light in weight and compact in dimension for retracting into thin wings. Some idea of the rigorous demands which the manufacturers of aircraft tyres, wheels and brakes have to face is given in the table below, in which the leading particulars of landing-wheel assemblies are compared for a modern supersonic aircraft and the Britannia 100 air liner.

	Britannia 100	Thin-wing supersonic aircraft.
Type of brake	Two-cylinder two-plate brake incorporating chromium-plated copper plates	Multi-cylinder two-plate brake using inorganic linings and steel plates
Normal landing—wheel load, lb.	13,500	13,200
Normal tyre pressure, lb. per sq. in.	152	275
"Brakes on" speed, m.p.h.	127	157
Normal mean drag force, lb.	3,880	3,930
Normal kinetic energy to be converted, ft.-lb.	6,450,000	10,000,000
Maximum normal rate of energy conversion, h.p.	1,320	1,640
Volume of tyre, wheel and brake, cub. ft.	6½	21

The energy dissipation requirements of future generations of aircraft may well be still more drastic, and to keep pace with them the Aviation Division of the Dunlop Rubber Company, Limited, Foleshill, Coventry, have recently installed a new dynamometer with a maximum kinetic energy of 66×10^6 ft.-lb. The machine has been constructed to the company's specification—based on the American Adamson machine—by Sir William Arrol and Company Limited, Glasgow.

With this dynamometer, which enables tests conforming to international airworthiness standards to be carried out, it is possible to test the tyre, wheel and brake together under closely-simulated operating conditions, whereas hitherto it has not been possible, in the United Kingdom, to test the wheel and tyre on the brake-testing rig.

Basically, the dynamometer which is shown in the illustrations above, consists of a large inertia flywheel of variable weight with horizontally movable carriages mounted on either side. An aircraft tyre, wheel and brake assembly is attached to one of the carriages and brought into contact with the periphery of the freely-rotating inertia wheel under predetermined conditions, to simulate the complete aircraft landing operation.

In the standard stopping test, designed to test the complete assembly under normal and emergency conditions, the tyre, wheel, and brake assembly is mounted on the axle of the selected carriage and the weight of the flywheel is adjusted to the required kinetic energy value at approximately the correct aircraft wheel speed. The inertia wheel is then accelerated by an electric motor until the predetermined speed is slightly exceeded, when the motor is declutched and pneumatic rams load the aircraft wheel assembly against the inertia-wheel rim. When the required speed is reached, the aircraft brake is applied hydraulically until the flywheel is brought to rest. The time needed to achieve this can be taken as a measure of the brake efficiency. By variations of this basic procedure, complete test schedules, which include the reproduction of all the conditions tyres, wheels and brakes are likely to be subjected to during service, can be carried out. To expedite testing programmes, provision is made for air-cooling the equipment on completion of a test.

The machine, which is 46 ft. long by 35 ft. wide, weighs approximately 160 tons and stands on a concrete bed weighing 180 tons. The diameter of the inertia wheel is 10 ft., and the rim is 2 ft. wide. The flywheel weighs 10 tons, but this weight can be increased by adding a series of thirty plates, of the same diameter as the flywheel, each weighing 1·18 tons, to make a maximum weight of 45½ tons. When not in use these plates are located on projections from the main bearing pedestals.

The inertia wheel is driven by a 400 h.p. variable-speed direct-current motor through a two-speed gearbox and clutch. At the maximum rotation speed of 560 r.p.m., an equivalent of 200 m.p.h. is achieved. The maximum kinetic energy value developed by the machine at full flywheel weight and revolutions per minute is, as already recorded, 66 million ft.-lb., which suggests that the dynamometer has sufficient capacity to meet the greater braking capacities that may be required in the future. At maximum weight, this kinetic energy value would be equal to 22 tons of aircraft weight per brake, or an aircraft of 176 tons with eight main wheels and brakes landing at 200 m.p.h.

Beneath the floor level is an emergency brake which also serves as a jack to raise the inertia wheel from its bearings when required. Tachometers on the flywheel and clutch shafts are connected to an electronic controller which keeps the revolutions of the wheel and clutch in phase. This is necessary as the clutch is disengaged during tests and excessive variation of speed would prevent re-engagement.

PNEUMATICALLY-LOADED CARRIAGES

Diametrically-opposed on either side of the inertia flywheel are the two horizontally movable carriages, each of which is controlled by a pneumatic ram. The smaller carriage ram exerts loads up to 25,000 lb., and the larger carriage, which caters for tyres up to 67½ in. in diameter, is capable of exerting loads up to 70,000 lb.

The console, from which the machine is controlled and test results are recorded visually, is divided into two parts, one for each carriage. The controls include means for adjusting the speed of the flywheel, and the approach speed of the test assembly towards the flywheel, and for applying the brakes.

The test data is visually recorded on dials indicating speeds, wheel load, brake pressure and torque during the test, the torque on the brake being taken out through a lever mechanism and measured electronically. A cathode-ray oscillograph with a long-persistent tube retains the torque curve image up to 1 minute after the test is completed. For future comparison and analysis, a sensitised paper record is also made by an electronic recorder. Provision is also made for the automatic operation of tests where specifications call for repeating cycles.

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DERMATITIS PROTECTION

A new silicone barrier preparation has been placed on the market by Lloyd-Hamol Limited, 3 St. James's-square, London, S.W.1. The preparation, which is for use against industrial dermatitis, has been given the name Syl, and is stated to be highly efficient as a protective.

END REACTIONS AND STRESSES IN PIPE-LINES

SIMPLIFIED CALCULATIONS FOR TWO AND THREE DIMENSIONAL LAYOUTS

By L. F. Randolph, B.SC., A.M.I.MECH.E.*

The methods for calculating expansion stresses in high-temperature piping have been worked out in a number of ways by several investigators. Engineers engaged in this field have adopted one or another of these procedures, depending on personal preferences or extent of their theoretical background. All these methods are however characterised by being extremely complicated, laborious and time consuming. Moreover, most engineers do not solve problems of this type often enough to develop the discipline required to obtain accuracy in a very tedious and lengthy calculation. The subsequent uncertainty makes it essential to have the work checked by an independent computer, with the result of further delays and of increasing the already large amount of work. The need for a quick and easy approach is therefore evident and it is the purpose of this paper to present a short-cut method for calculating the flexibility of two and three-dimensional piping systems, which reduces the calculating time by 80 to 90 per cent. and gives solutions within about ± 20 per cent. of an accurate method. The work is based on an article by T. E. Bridge,[1]† in which he reviews the theory due to C. T. Mitchell[2] supporting this method, shows up its limitations and proposes further simplifications, which shorten the calculating time and improve somewhat the accuracy obtained.

The author of this article has had the opportunity to subject the proposed method to a severe test in the course of stressing-out pipe-lines for various design sections, in which case the grapho-analytical method of investigation was used to provide the "accurate" results.‡ During this work various other features have been brought to light, which have either been ignored by Bridge or erroneously assumed as correct; these have been included in this article.

The procedure to be adopted in solving actual problems is outlined step by step below; special references are made to modifications that may be necessary to assure reasonable accuracy for individual pipe systems. The three worked examples should also materially assist in understanding this method, at the same time pinpointing the errors to be expected due to the simplifications employed.

In order to make this article as far as possible self-sufficient for the purpose of calculating thermal stresses, graphs have been included which show the temperature variations of the modulus of elasticity and linear expansion coefficient for medium carbon steels and austenitic steels. Furthermore, Appendix I deals briefly with the maximum shear-strain energy criterion of elastic failure of ductile materials under the action of combined stresses.

* Of Imperial Chemical Industries, Limited, Billingham Division.

† All references will be given in the bibliography at the end of the second part of the article.

‡ The second part of this article, to be published later, comprises a number of worked examples and a brief analysis of the grapho-analytical method of investigation.

ANALYSIS

FLEXIBILITY THEORY

No matter how complicated the system of restraining forces and moments at a pipe anchor, they may all be compounded into a single resultant force acting on the pipe. The line through which this resultant force acts will be called the thrust axis.

A simple two-dimensional piping system is shown in Fig. 1a, opposite, and the thrust axis is drawn on the sketch to aid visualising the flexing of the pipe. The left end of the pipe is shown as anchored but the anchor at the right end has been replaced by an imaginary rigid arm. On application of the force F to the rigid arm, the pipe will bend causing a deflection Δ in the direction of the force at the arm. In solving the problem this deflection is made equal to the expansion of the pipe between anchors.

In considering the effect of the force F on a small pipe element dL, located a distance Y from the thrust axis, it is clear that the bending moment on this element dL is

$$m = \mathrm{F\,Y} \quad . \quad . \quad . \quad (1)$$

where m is the bending moment on the pipe, in lb.-ft.

The change in slope of a short element of pipe dL ft. is

$$d\phi = \frac{144\, m\, d\mathrm{L}}{\mathrm{E\,I}} \quad . \quad . \quad . \quad (2)$$

Substituting equation (1) in (2)

$$d\phi = 144\ \mathrm{F\,Y}\ \frac{d\mathrm{L}}{\mathrm{E\,I}} \quad . \quad . \quad (3)$$

As the angle $d\phi$ is in radians, the effective motion of the rigid arm at the thrust axis resulting from the angular displacement will be $\mathrm{Y} \times d\phi$; hence $d\Delta = \mathrm{Y}\, d\phi = \frac{144\ \mathrm{F}}{\mathrm{E\,I}} \times \mathrm{Y}^2\, d\mathrm{L}$ ft., and, integrating,

$$\Delta = 1{,}728\ \frac{\mathrm{F}}{\mathrm{E\,I}} \int \mathrm{Y}^2\, d\mathrm{L} \text{ in.} \quad . \quad (4)$$

When considering a small pipe element in the same plane as the thrust axis but perpendicular to it, it can be readily seen that equations (1) to (4) apply equally well (Fig. 1a).

The condition of an element of pipe perpendicular to the plane containing the thrust axis is shown in Fig. 1b. In this figure the element dL is in pure torsion. Equation (1) ($m = \mathrm{F\,Y}$) applies as before but equation (2) becomes

$$d\phi = 144\ \frac{m\, d\mathrm{L}}{\mathrm{G}\, \mathrm{I}_p} \quad . \quad . \quad (5)$$

where G is the modulus of rigidity, lb. per sq. in.

I_p is the polar moment of inertia of the pipe section, in.[4]

Furthermore,

$$\mathrm{I}_p = 2\mathrm{I} \quad . \quad . \quad . \quad (6)$$

and

$$\mathrm{G} = \frac{\mathrm{E}}{2{\cdot}6} \quad . \quad . \quad . \quad (7)$$

taking Poisson's ratio as 0·3.

Substituting equations (1), (6) and (7) in equation (5)

$$d\phi = \frac{144\ \mathrm{F\,Y}\, d\mathrm{L} \times 1{\cdot}3}{\mathrm{E\,I}} \quad . \quad (8)$$

Also, as $d\Delta = \mathrm{Y}\, d\phi$ ft.,

$$\Delta = 1{,}728\ \frac{\mathrm{F}}{\mathrm{E\,I}} \times 1{\cdot}3 \int \mathrm{Y}^2\, d\mathrm{L} \text{ in.} \quad (9)$$

As the 30 per cent. increase in the flexibility of a straight pipe in torsion would only add complexity to the calculation it is proposed to disregard the factor of 1·3, which means in effect that the factor of safety is raised by a small amount.

It is therefore clear that the orientation of the pipe may be ignored, and the following formula may be used to calculate flexibility, no matter how the pipe is tilted with regard to the thrust axis:

$$\Delta = 1{,}728\ \frac{\mathrm{F\,M}}{\mathrm{E\,I}} \quad . \quad . \quad (10)$$

NOMENCLATURE

- D_i bore diameter of pipe, in.
- D_m mean diameter of pipe, in.
- D_o outside diameter of pipe, in.
- dL element of pipe length, ft.
- E modulus of elasticity, lb. per sq. in.
- e expansion factor of pipe material, in./100 ft.
- F force applied to the rigid arm to simulate the effect of anchoring the pipe, lb.
- F_x, F_y, F_z component forces, lb.
- f longitudinal bending stress due to thermal expansion in a straight pipe, lb. per sq. in.
- f_b longitudinal bending stress at a pipe bend, lb. per sq. in.
- f_e equivalent stress, lb. per sq. in.
- f_{p1} longitudinal stress due to internal pressure, lb. per sq. in.
- f_{p2} hoop stress due to internal pressure, lb. per sq. in.
- G modulus of rigidity, lb. per sq. in.
- I moment of inertia of pipe cross-section, in.[4]
- I_p polar moment of inertia of pipe cross-section, in.[4]
- K Karman flexibility constant (3rd approximation) $\mathrm{K} = \frac{252+739{,}12\lambda^2+2{,}446{,}176\lambda^4+2{,}822{,}400\lambda^6}{3+3{,}280\lambda^2+329{,}376\lambda^4+2{,}882{,}400\lambda^9}$
- L length of straight pipe between two reference points, ft.
- L_a true distance between anchors, ft.
- L_b net equivalent length of a pipe bend, ft.
- L_b' gross equivalent length of a pipe bend, ft.
- M 2nd moment $= \int \mathrm{Y}^2\, d\mathrm{L}$, ft.[3]
- M′ product moment $= \int \mathrm{X\,Y}\, d\mathrm{L}$, ft.[3]
- m bending moment, lb.-ft.
- M_b additional 2nd moment due to the flattening effect at the pipe bends, ft.[3] It is the net increase in the 2nd moment over that already included in a square corner assumption (or 45 deg. chord assumption).
- P internal pressure, lb. per sq. in.
- P_1 P_2 principal stresses, lb. per sq. in.
- R radius of the centre line of a pipe bend, in.
- T difference between operating and pipe installation temperature, deg. C.
- t pipe wall thickness, in.
- Y perpendicular distance from the element of pipe dL to the thrust axis, ft.
- Y_b perpendicular distance from the square corner assumed in place of the pipe bend (or from the mid-point of the assumed 45 deg. chord) to the thrust axis, ft.
- Y_d the arithmetic difference between two successive values of Y, ft. It is always taken as positive.
- $(\mathrm{Y}^3)_d$ difference between the cubes of successive values of Y, ft.[3]. N.B.: It is *not* the cube of the difference of the Y values.
- α transverse bending stress factor
- β longitudinal bending stress factor

  } to correct for stress concentration, when a pipe bend flattens.
- Δ deflection of the rigid arm parallel to the thrust axis, in.
- Δ′ deflection of the rigid arm perpendicualar to the thrust axis, in.
- Δ″ vector sum of Δ + Δ′, in.
- δ angle between the thrust axis and the vertical co-ordinate axis Z, degrees.
- δ′ angle between the thrust axis and the vertical co-ordinate axis Z in an elevation view, which is perpendicular to the line of anchors in the plan view, degrees.
- ε the angle between the projection of the thrust axis into the plan view (XY-plane) and the X-axis, degrees.
- θ angle between the thrust axis and a line joining the anchors, degrees.
- θ_p angle θ projected into the plan view, degrees.
- θ_e angle θ projected into the elevation view, degrees.
- θ′ angle defined by the equation $\theta' = \tan^{-1}\frac{\Delta'}{\Delta}$, degrees.
- λ pipe factor $= \frac{4\, t\, \mathrm{R}}{\mathrm{D}_m{}^2}$.
- φ the angular displacement of the rigid arm under the action of the force F, radians.

where

$$M = \int Y^2 \, dL. \quad . \quad . \quad (11)$$

THE SECOND MOMENT

In order to facilitate the setting up of a tabular method, a formula will now be derived to calculate the second moment of a straight length of pipe inclined at an angle with the thrust axis. In Fig. 2, below, one end of such a pipe is located Y_a and the other end Y_b distant from the thrust axis. The length of the pipe is L. From similar triangles

$$l = L \frac{(Y - Y_a)}{(Y_b - Y_a)}. \quad . \quad (12)$$

On differentiation let, for convenience, $dl = dL$. Therefore

$$dL = \frac{L \, dY}{(Y_b - Y_a)}. \quad . \quad (13)$$

Substituting (13) in (11)

$$M = \frac{L}{(Y_b - Y_a)} \times \int Y^2 \, dY.$$

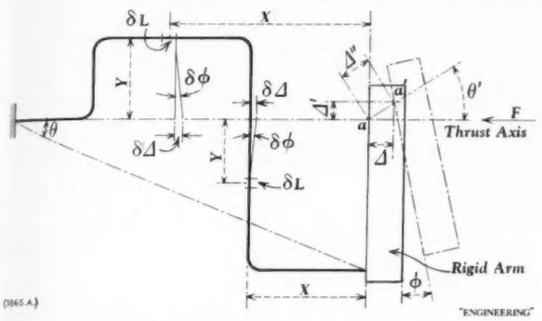


Fig. 1a (left) The effects produced by the applied force acting on pipe elements in the plane of the thrust axis.

Fig. 1b (right) The effect produced by the applied force acting on a pipe element in pure torsion.

On integrating between the limits $Y = Y_b$ and $Y = Y_a$,

$$M = \frac{(Y_b^3 - Y_a^3) \times L}{(Y_b - Y_a) \times 3}$$

or

$$M = \frac{(Y^3)_d \times L}{3 \, Y_d}. \quad . \quad . \quad (14)$$

Note that $(Y^3)_d$ is equal to the difference between successive values of Y^3. (It is *not* equal to the cube of Y_d.)

When $Y_b = Y_a$, equation (14) cannot be used, but it is obvious that under these conditions

$$M = Y^2 L. \quad . \quad . \quad (15)$$

The total moment thus obtained will be used to determine the thrust F. The following equation (derived from the familiar beam stress formula) will then be used to calculate the longitudinal bending stress:

$$f = 6 \times F \times Y \times \frac{D_0}{I}. \quad . \quad (16)$$

LOCATION OF THRUST AXIS

All of the more accurate calculating methods described in the literature run into very serious complications in their attempts to locate the thrust axis of a pipe system with precision. It can, however, be demonstrated that a considerable error in locating the thrust axis gives only small errors in the answer, and it is therefore proposed that an empirical method be used in determining the position of the thrust axis.

In order to locate the thrust axis it is first of all assumed that the anchors are perfectly rigid, which means that the position of the axis must be such as not to produce any angular displacement of the rigid arm (Fig. 1*a*). The angular displacement of this arm may be obtained by integrating equation (3) to give

$$\phi = 144 \frac{F}{E I} \int Y \, dL. \quad . \quad (17)$$

Therefore, as ϕ is to be zero, $\int Y \, dL = 0$ also, and thus it can be seen that this first assumption (rigid anchors) determines that the thrust axis must pass through the centre of gravity of the piping system.

There is still another condition which has to be fulfilled, in that there must be no sideway movement of the rigid arm as the force F is applied.

It will be assumed that on removing the force F (Fig. 1*a*) the point *a* on the rigid arm will spring back to point *a′*. The component deflection Δ is parallel to the thrust axis and Δ′ is the component perpendicular to the thrust axis.

It can be demonstrated by referring to Fig. 1*a* that the sideways deflection is given by

$$\Delta' = 1{,}728 \frac{F \, M'}{E \, I}. \quad . \quad (18)$$

where

$$M' = \int X \, Y \, dL \text{ is the product moment.} \quad (19)$$

X and Y being the distances from the pipe element *d*L to the rigid arm measured along and perpendicular to the thrust axis, respectively.

By definition the angle θ'—the angle between the thrust axis and the direction of movement of the rigid arm—is given by

$$\theta' = \tan^{-1} \frac{\Delta'}{\Delta} = \tan^{-1} \frac{M'}{M}. \quad . \quad (20)$$

In the following equation θ is the angle between the thrust line and a straight line connecting the anchors. It is in a sense a measure of the error made by the Mitchell assumption.* For special reasons, the thrust axis in Fig. 1*a* is not shown in its correct location. If it were, angle $\theta = \theta'$ and the following equation would apply:

$$\Delta = \Delta'' \cos \theta. \quad . \quad . \quad (21)$$

The amount the pipe expands, Δ in., is determined from the factor of expansion *e* of the pipe in inches per 100 ft. and the true distance, L_a ft., between the anchors

$$\Delta'' = e \times L_a. \quad . \quad . \quad (22)$$

Equation (21) may be substituted in equation (10) to obtain

$$F = \frac{\cos \theta \, \Delta'' \, E \, I}{1{,}728 \, M}. \quad . \quad (23)$$

The problem therefore is to choose an orientation for the thrust axis that will produce a motion of the rigid arm from point *a′* to point *a* as the force F is applied. This force is equivalent to the reactions produced as the pipe expands. In other words, the deflection of the rigid arm must be in the direction in which the pipe expands. This means that if the thrust axis is correctly orientated $\theta = \theta'$.

Hence the exact procedure for the determination of the thrust axis location would be as follows:

(*a*) assume an arbitrary value of θ, the angle between thrust and anchor line;

(*b*) by calculating the second moment M and product moment M′ it is possible to determine $\theta' = \tan^{-1} \frac{M'}{M}$; and

(*c*) if $\theta' \neq \theta$, a new angle θ must be chosen and the corresponding θ' calculated. If necessary this process must be repeated.

* Mitchell[2] suggests in his original paper that the thrust axis should be drawn through the centre of gravity of the piping system and also "parallel to the direction in which the expansion takes place, i.e., parallel to a line drawn between the anchors." It is shown by Bridge that this simplification may and does lead to very serious errors.

EMPIRICAL LOCATION OF THRUST AXIS

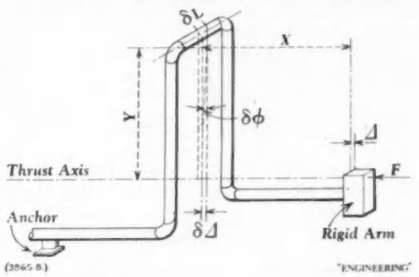
However, this trial and error method would defeat the whole object of the author's analysis, which is to give reasonably accurate answers with a considerable saving in calculating time, and it is hence proposed to outline an empirical method for locating the thrust axis:

(*a*) draw a line through the centre of gravity (c.g.) of each half of the system (the centre of gravity axis); the c.g. of the whole system will of course lie midway between them.

(*b*) draw a line parallel to the direction in which expansion takes place (the anchor line) through the c.g. of the system; and

(*c*) draw the thrust axis halfway between the above axes. In other words bisect the angle between (*a*) and (*b*).

As a result of considerable study, Bridge has decided that it is usually unnecessary to locate the thrust axis accurately when using this short-cut method. There are many problems where accuracy of a high order is not required, and it is usually cheaper to increase the factor of safety than it would be to refine the calculation. He believes that, if a probable error of 10 per cent. can be tolerated, it is justifiable to simply draw in the thrust axis without making any lengthy calculation as to the correct positioning of the centre of gravity axis, point (*a*) above. The justification lies in the following reasons:—



(1) A considerable amount of time is saved, especially in a complicated piping system;

(2) The eye is very sensitive to errors made in locating the c.g. It is surprising how often a designer will make a mistake in calculating its correct location, and being immersed in figures he draws the thrust axis through a point which is quite obviously not the c.g.;

(3) Furthermore, as has been mentioned before, only a small change is made in the actual answer by a very appreciable mis-location of the thrust axis, as the additional second moment at one side of the axis is almost cancelled by the reduction in the second moment on the other side; and

(4) The assumption of the thrust axis having to pass through the c.g. of the piping is in any case inaccurate, as anchors are not likely to be perfectly rigid.

The author feels, however, that to start off with an assumed line which depends so much on

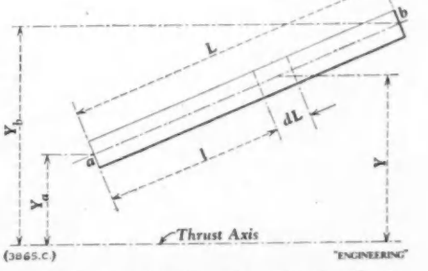


Fig. 2 A straight elementary length of pipe inclined at an angle with the thrust axis.

the sensitivity of the eye of the average calculator is psychologically unsound. It means in fact that he will not have much confidence in the otherwise reasonable accuracy of his final result, and the addition of a large safety factor will certainly not improve his sceptical outlook. Furthermore, even the experienced man will find it difficult to spot the c.g. axis by eye if the system is composed of pipes of different moments of inertia, when " equivalent " lengths will have to be taken into account. And all this uncertainty arises for the want of a few minutes of a rough calculation. In all the problems examined by the author, the time spent in locating this axis never exceeded 15 minutes, and in the majority of cases was very much less.

As for point (3), it is only fair to say that in pipe layouts where the pipe-line in one direction is not very much greater than along the other two perpendicular directions, the magnitude of the thrust force will not change very much by an inaccurate assumption of the thrust-axis position. The bending stresses, however, will be affected, and it is certain that the position of the maximum bending stress as calculated, apart from being different in magnitude, will in many cases bear no relation to the location at which it actually occurs. When the pipe is very much longer in one direction, then even the size of the thrust force may be materially altered by an injudicious initial assumption. All these considerations lead to the conclusion that the short time spent on finding the c.g. of the two halves of the pipe system is well justified, both in giving the person concerned more confidence and, which may be more important, giving more accurate results.

THIN-WALLED CURVED PIPES IN BENDING

It is the purpose of the following paragraphs to develop a simple method of correcting the calculations so far outlined by including the actual effect of the flattening at a bend on the flexibility of the piping.

It is proposed to obtain a measure of the flexibility of a pipe system containing bends by first calculating the second moment assuming square corners, and then to express the extra flexibility produced by the flattening effect at each elbow as an equivalent additional length of straight pipe. The additional net second moment of the bend, which will have to be added algebraically to the total previously calculated, will therefore be

$$M_b = L_b Y_b^2 . \quad . \quad . \quad (24)$$

where

L_b is the net equivalent length of the bend over that already included in the " square-corner " assumption and Y_b^2 the square of the distance from the assumed square corner to the thrust axis.

Consider a 90 deg. bend with a radius R inches. Such a bend will have a true length of $\frac{\pi R}{24}$ ft.

Its gross equivalent length, taking into account its greater " springiness " will be

$$L_b' = \frac{\pi R}{24} \times K \quad . \quad . \quad (25)$$

where K is the Karman flexibility factor.*

In order to calculate the net equivalent length of the bend, it is necessary to subtract the actual length of the pipe included in a square, corner assumption from the gross equivalent length of the bend. Thus

$$L_b = L_b' - \frac{2R}{12} \quad . \quad . \quad (26)$$

* Karman originally calculated this factor as $K = \frac{10 + 12\lambda^2}{1 - 12\lambda^2}$ where $\lambda = \frac{4t \times R}{D_m^2}$. Because of the assumptions made by him this factor is only valid for values of $\lambda > 0{\cdot}5$. For smaller values of this pipe factor a second and a third closer approximation of the value of K have been made.[7] The latter is

$$K_3 = \frac{252 - 73{,}912\lambda^2 + 2{,}446{,}176\lambda^4 + 2{,}822{,}400\lambda^6}{3 + 3{,}280\lambda^2 + 329{,}376\lambda^4 + 2{,}822{,}400\lambda^6}$$

which has in fact been used to draw the graph to be given in Fig. 6.

and substituting (25) in (26)

$$L_b = R \times \frac{K}{7{\cdot}64} - \frac{R}{6} .$$

Therefore

$$\frac{L_b}{R} = \frac{K}{7{\cdot}64} - \frac{1}{6} . \quad . \quad (27)$$

Fig. 6, which will show the flexibility and stress coefficients for plain bends and the equivalent lengths of bends, indicates, *inter alia*, the dependance of the ratio $\frac{L_b}{R}$ on the pipe factor λ; the net equivalent length, L_b (ft.), is therefore obtained by multiplying the appropriate value deduced from the graph by the bend radius R (inches). It is recognised that the corrections achieved by the use of Fig. 6 are only approximate, but sufficient accuracy will be obtained for all practical purposes. Example 2 will illustrate the manner in which the flattening effect correction is applied.

For a three-dimensional problem it is usually not desirable to apply a flattening-effect correction which if carried out might only lead to unsafe answers. Furthermore, the correction would become quite involved due to the fact that only partial credit may be taken for flattening effect at bends which are not in pure bending.

STRESSES IN CURVED PIPES

Flattening of a curved pipe causes a stress distribution different from that in straight pipes. The law of linear distribution of bending stresses no longer holds. The maximum fibre stress does not occur at the extreme distance from the neutral axis and its intensity is larger or smaller than that obtained from the linear law. Professor Hovgaard,[6] as a result of theoretical and experimental research, has introduced the stress coefficients α and β, thus modifying the stress formulae to:

longitudinal bending stress

$$= \beta \times \frac{F Y \times 6 D_0}{I} = \beta \times f \quad . \quad (28)$$

and transverse stress

$$= \alpha \times \frac{F Y \times 6 D_0}{I} = \alpha \times f \quad . \quad (29)$$

where $\beta = \frac{2K}{3}\sqrt{\frac{6\lambda^2 + 5}{18}}$ for $0{\cdot}7 < \lambda < 1{\cdot}472$

and $\beta = K\left[\frac{6\lambda^2 - 1}{6\lambda^2 + 5}\right]$ for $\lambda > 1{\cdot}472$

and $\alpha = \frac{18\lambda}{1 + 12\lambda^2}$ for the first approximation to λ.

(Fig. 6 is reproduced from graphs in Reference 3, based on a third approximation of the radial displacement curve of the centre line of the initially circular cross-section, thus covering smaller values of λ.)

It is customary at the present* to ignore the transverse stress due to the external moment applied, although it will in many cases reach the yield stress of the material, while the longitudinal stresses will be considerably less. Hovgaard investigated such cases very carefully, and came to the conclusion that local yielding relieved the transverse stress at any point where it exceeded the yield stress, with the result of creating a more even distribution of transverse stress across the wall thickness at such points. The result of his work led him to believe that it was the longitudinal stress which had the greatest effect on the failure of the bend, and that a bend would not take any permanent set until the maximum longitudinal stress at the middle surface had closely approached the yield stress of the pipe material.

* In the paper[7] by Ford and Gross attention is focused on cases of pipe bend failures due to overstressing exhibiting longitudinal cracks in the plane perpendicular to the plane of bending, thus indicating that failure is due to excessive transverse stress. Moreover, it is pointed out that even local yielding is undesirable, as the regions affected show a greater sensitivity to any corrosive action of the carried fluid. Taking therefore the first yield of the material as being the critical condition, the shear-strain energy theory is adopted as the criterion of failure. The principal stresses are based on the 3rd approximation to λ and are corrected for a change in length of the centre line of the cross section; this change in length was ignored by Karman in his original analysis. Judged by the experimental results the calculated results show that the peak stresses are accurately forecast, and that the general pattern and trend with λ are in good agreement. It is also concluded that the stress condition for the pressure-less bend will be the most critical one, a circumstance which simplifies the design problem.

PROCEDURE

THREE-DIMENSIONAL LAYOUT

The approach to the three-dimensional problem is similar to that of the two-dimensional problem, though the latter is simpler, as only one view has to be dealt with. For the three-dimensional case the following procedure is suggested.

(1) Prepare a plan view of the piping, squaring out the bends to simplify the calculation. *Note:* If the radius of the pipe bends is large in relation to the dimensions of the system, it may be necessary to approximate the bend with a chord at 45 deg. plus two short legs, having approximately the same length as the bend.

(2) Draw a straight line between anchors, and an elevation of the piping normal to this line. This elevation will show the true distance L_a between anchors, and this distance can be scaled.

(3) Equation (22) is then solved ($\Delta = e \times L_a$). The coefficient of expansion e of the pipe, if of carbon or austenitic steel, can be read off Fig. 7 (to be published later).

(4) The piping is then divided into two sections with the same equivalent length of piping in each section (see note, para. 5 following).

(5) The c.g. of each section is roughly determined by calculation. The points P and Q will show both in plan and elevation.

Note:

(*a*) If the pipe is not all of the same diameter, equivalent lengths for the larger-diameter stretches are to be calculated in which the true length is reduced by a factor equal to the ratio $\frac{I_s}{I}$ where I_s is the smallest moment of inertia of the pipe system and is used as standard, and I is moment of inertia of the actual pipe section.

(*b*) If one section is of much larger diameter, it may be ignored altogether and assumed to have zero weight, as it will have virtually no effect on the flexibility of the system.

(*c*) If a portion of the pipe-line is guided or otherwise restrained from bending it must also be assumed to have no weight, insofar as locating the c.g. is concerned.

(6) The line P Q (the c.g. axis) is drawn and the c.g. of the whole system, point O, is then indicated.

(7) A line parallel to a line connecting the anchors is then drawn through the point O in both plan and elevation.

(8) The thrust axis is then located midway between the two axes indicated in paragraphs (6) and (7), again both in elevation and plan.

Note: In the problems of the type to be examined in Example 3, when the angle between the above recommended thrust axis and the long stretch of piping is small both in plan as well as elevation, and when a small rotation of this empirical axis would lead to considerable changes in the total second moment, it is suggested that the axis through the c.g. should be taken as the thrust axis. This will result in all cases in a smaller second moment and hence a larger thrust force at the anchor points than would otherwise be the case, and will bring the answers in line with the results of more refined methods. When, on the other hand, the long stretch of piping in one view

is only the result of the projection of an irregular pattern from the other view, in which a rotation of the thrust axis would not materially affect the value of the second moment, the initial location of the thrust axis should be retained.

(9) The angle included between the thrust axis and Mitchell's axis (parallel to the anchor line, para. 7) is measured: θ_p = the angle in plan, θ_e = the angle in elevation. Calculate $\cos\theta = \cos\theta_e \times \cos\theta_p$, to be used in equation (23) to determine the force F.

(10) Each corner of the system in both plan and elevation is labelled. A point on the pipe in plan must be projected over into the elevation and carry the same label in both views.

(11) Each point where the pipe crosses the thrust axis is labelled in both plan and elevation. These points must show the same label after their projection into the other view.

(12) The distance Y—the distance from the point to the thrust axis—is then measured for all points in both planes. The values are tabulated in a manner similar to that shown in the examples.

(13) All values of Y are squared, and the results entered in separate columns for both plan and elevation.

(14) The square root of the sum of the two values of Y^2 for each point gives the true distance from the thrust axis for the point in question.

(15) Each value for Y obtained in para. (14) is cubed.

(16) Y_d, which is the numerical difference between successive values of Y, is calculated and is always taken positive.

(17) Similarly $(Y^3)_d$, the positive difference between successive values for Y^3, is determined.

Note: $(Y^3)_d$ is not equal to the cube of the difference $(Y_d)^3$.

(18) Values of L, the true length of pipe between successive points shown either on plan or elevation, are measured and tabulated.

Note: If the system consists of pipes of various diameters, an "equivalent" length must be taken, in which the true lengths of the larger-diameter pipes are reduced by the multiplication of a factor equal to the ratio of the moment of inertia of the smallest-diameter pipe to the moment of inertia of the pipe section considered.

Furthermore, a portion of the pipe-line which is guided or otherwise restrained from bending, has its length reduced to zero in equations (14) and (15), as it will have no effect on the flexibility of the system.

(19) Equation (14) is solved for values of $3M = \dfrac{(Y^3)_d \times L}{Y_d}$ for each section of the pipe and tabulated as shown in the examples. If $Y_d = 0$ or very nearly zero, equation (15), $3M = 3Y^2L$ is solved, as equation (14) cannot be used under these conditions.

(20) The total value of 3 M for the system as a whole is obtained by addition, and divided by 3 to give the second moment M.

(21) If the calculation is to be corrected for flattening effect the value for L_b can be found from equation (27) or Fig. 6, and used to determine the second moment of each bend separately: $M_b = L_b \times Y_b{}^2$. These values of M_b are added to the value M previously calculated, thus giving a new total second moment.

Note: If a 45 deg. chord is used to represent a large pipe bend, L_b can still be calculated with negligible error from equation (27) or Fig. 6, but Y_b will be the distance from the midpoint of the chord to the thrust axis.

For three dimensional problems these corrections should not be applied.

(22) Equation (23) is solved for F; thus

$$F = \frac{\cos\theta \, \Delta \, E \, I}{1728 \, M}.$$

If the system consists of pipes of various sizes, I in this equation is the smallest moment of inertia of the pipe layout (see note 5*a*). The calculation of $\cos\theta$ was explained in para 9.

(23) The force F may be resolved into components (see Appendix II).

(24) The restraining moments at the anchors can be determined from the product $F \times Y$, where Y is the vertical distance of the appropriate anchor from the thrust line.

Note: If it is desired to find the component moments in the three principal planes at the anchors, e.g., for the purpose of finding the shear stresses in anchor bolts, etc., multiply the component forces at the centre of gravity by their offsets from the point in question.

(25) Equation (16) is solved for the maximum bending stress at an anchor, so that

$$f = F \times Y \times \frac{6\,D_o}{I} \text{ lb. per sq. in.}$$

Similarly, equation (28) for the maximum bending stress at a pipe bend is given by

$$f_b = \beta \times f = \beta \times F \times Y \times \frac{6\,D_o}{I} \text{ lb. per sq. in.}$$

Note: For a square corner, assume Y to be equal to the perpendicular distance between corner and thrust axis.

For a 45 deg. chord assume Y to be the perpendicular distance between that point of the chord which is farthest removed from the thrust axis and the thrust axis.

(26) The above values for thrust, moments and stresses for the "cold" state may be reduced by one-third, if a cold pull up of 66·67 per cent. of the computed expansion is applied.

(27) Similarly, in order to obtain an indication of their values in the hot state, the same quantities may be reduced by two-thirds and by the ratio of the modulus of elasticity E for the hot state over E for the cold state when a cold spring of 66·67 per cent. is designed for. (Temperature variations of E for two kinds of steel will be given in Fig. 8, subsequently.)

Note: (*a*) These reductions both for para (26) and (27) are only permissible when there is no danger of loss of cold spring, e.g., due to swivelling at joints during erection or yielding when in the cold state. If there is any likelihood of such a loss, the full thermal expansion should be assumed in calculating the "cold" stresses, and 66·67 per cent. of the computed thermal expansion in calculating the "hot" stresses.

(*b*) Under creep conditions, that is at temperatures above 450 deg. C., it would be wise to design for:—

(i) the cold condition, by assuming a cold pull up equal to 100 per cent. of the computed thermal expansion; and

(ii) the hot condition, by leaving 33·33 per cent. of the thermal expansion to create end forces and stresses.*

(28) Determine the equivalent stress f_e (see appendix I) for the hot state, when the material is subject to combined stresses, i.e., to more than one principal stress.

SUMMARY

It is recognised that the use of a simplified method for the evaluation of the thermal stresses in pipe systems must entail slight concessions in accuracy. On the other hand there is no gainsaying the advantage to be derived from having a method which may be used by inexperienced calculators with a minimum of time consumed. The task of checking perhaps 25 to 30 rather complicated piping configurations for safe operation at high temperatures—which may well be the result of initiating a new project—by any of the more accurate methods currently described in the literature is almost prohibitive, both in time and design costs. A mere visual inspection of the space taken up for the solution of any particular problem by this method, compared with some published methods,[3,4,5] should leave very little doubt that the calculating time can be reduced by as much as 80 to 90 per cent. A more careful study of this simple method, plus a knowledge of the intricacies of the accurate methods, their chief sources of errors—"sign" troubles—their insistence on the soul-destroying procedure of evaluating constants on the long trail to the final goal, the uncertainty of the accuracy of the final results, which may be the outcome of several arithmetical mistakes, etc., should remove even the last traces of pessimism. In the hope that this has been accomplished successfully it only remains to give an idea of the sacrifice in accuracy involved.

The analyses presented below are based on the experience gained by the author, when applying both the grapho-analytical and elastic-centre method as well as the method described to a great number of problems arising in the course of normal design work.

Two-Dimensional Pipe Layout.—The proposed method resulted in forces which were within −12 per cent. and + 6·5 per cent. of the "accurate" answers in six cases out of seven. In the seventh case, the discrepancy was 21 per cent. At the same time the maximum moments (and hence stresses) were within − 8 per cent. and + 7 per cent. of one another respectively, except in one case where the discrepancy was −16 per cent.

Three-dimensional Pipe Layout.—The layout differences in the determination of forces, as between the proposed method and the accurate method were + 15 per cent. and − 14 per cent., and the corresponding moment differences were + 7·5 per cent. − 15 per cent. in eight cases.

One further point is very noteworthy. In most cases, except where the pipe factor λ is very small, an approximate layout is assumed when using one of the refined methods, that is to say a layout in which the circular arcs of the bends are replaced by straight parts. This approximation, while easing the task of solving for the end reactions and also cutting down the time required for solution, does not materially affect the formidability and laboriousness of the calculations involved. Yet it is noticeable that in the two problems in which both "accurate" methods have been applied the resulting end thrusts vary by − 18 per cent. and + 9 per cent., and the maximum bending moment by − 12 per cent. and + 4 per cent.; the errors thus incurred are comparable therefore with those obtained by the simplified method.

Three-Dimensional Pipe Layouts (and Two-Dimensional Pipe Layouts).—It has been found by the author that the empirical positioning of the thrust axis midway between the centre of gravity axis and the Mitchell axis would lead to a serious under-estimation of the maximum stresses in pipe systems in which a long straight pipe is the dominant factor. In these particular cases it is advisable to assume that the thrust axis is coincident with the centre of gravity axis, which will be borne out by a study of the three problems used to illustrate the method.

Two- or Three-Dimensional Pipe Layouts with Two Hinges.—When both ends of the pipe system are held in such a way as to permit rotation but to stop translatory motion, the proposed method can be used, giving very accurate results. In these cases, where the anchors act as if they were hinges, and therefore offer no resistance to moments, the thrust axis must be the line connecting the hinges and hence the determination of the c.g. is superfluous. In all cases the positions of the maximum moments are predicted correctly.

Finally, it may therefore be said that in two- or three-dimensional problems, where the centre of gravity axis of the system is located by a rough calculation, the empirical positioning of the thrust axis midway between the former and

* The stresses in a pipe-line when exposed to temperatures of 450 deg. C. and above will relieve themselves by creep relaxation, so that after a comparatively short period at the working temperature the pipe will be in the same state of stress as if the cold pull up had been practically 100 per cent. of the computed thermal expansion, irrespective of the actual value of the initial cold pull up; that is to say, in the ideal case, the only stresses present are those due to internal steam pressure. In cooling down the pipe will have to withstand stresses produced by a cold pull up equivalent to 100 per cent. of the computed thermal expansion.

the line connecting the *rigid* anchors (Mitchell's axis) will give resultant thrust forces and maximum bending stresses which are within ± 20 per cent. of the answers obtained by an "accurate" calculation.

In cases where the above proposed thrust axis would include a small angle with a very long stretch of piping both in elevation and plan, the line of action should be considered to be coincident with the c.g. axis. The accuracy thus achieved will be of the order quoted above.

When the pipe bend radii are large compared with the dimensions of the pipe system, the assumption of a square corner layout will result in thrust forces and anchor moments which are lower, and pipe bend stresses which are higher than those obtained by a more refined method. The discrepancies will still be within the accuracy range quoted, except at the bends where they may be on the large, yet safe, side. As long as these considerations are borne in mind, there does not seem to be any necessity to introduce a 45 deg. chord substitution for the pipe bends, which if carried out will lead to up to approximately 20 per cent. over-estimation of all the stresses.

The method can also be used for determining the stresses in pipe layouts where both ends are hinged, but *not* without further investigation for cases where only one end is allowed to rotate while the other one is fixed, or where the anchors are subject to movement due to external influences. It is clear that under these conditions new empirical thrust axes will have to be found. But it seems doubtful at the present moment whether a simple rule, on similar lines to the one proposed, can be put forward for problems where either the thrust axis does not pass through the c.g. or where its location will depend on the individual movements of the anchors.

To be concluded

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HIGH-TEMPERATURE MATERIALS

Jubilee of the Thermal Syndicate

Industrial laboratories are all familiar with the products and the trade mark, "Vitreosil," of the Thermal Syndicate Limited, manufacturers of fused quartz and silica crucibles, tubes and other ware, and high-temperature refractories, Neptune-road, Wallsend, Northumberland.

The present firm is the result of the amalgamation of two originally separate companies, namely, the Thermal Syndicate Limited, incorporated on August 3, 1906, and the Silica Syndicate Limited, which came into being in June, 1906. In 1917, the latter company was acquired by the Thermal Syndicate and, since 1920, all operations have been carried on at Wallsend. This year the company is celebrating its golden jubilee and to mark the occasion a book, entitled *The Thermal Syndicate Limited*—1906–1956, has been published. It is stated in the foreword that the book "tells the story of the birth and progress of an entirely new industry, and is a record of yet another important British contribution to modern industrial achievement in the fields of science and engineering."

In addition to recounting the history of the firm and the individuals connected with it, the book traces the progress of the transparent and translucent products made and shows how their capacity to withstand relatively high temperatures and their property of resisting thermal shock caused them to be adopted for an increasing number of applications. These include absorption vessels for hydrochloric acid gas, cathode rings for tank-form mercury rectifiers, liners for the water-cooled components of electric induction furnaces and sheaths for quick immersion thermocouples for steelworks. Optical-quality transparent fused quartz was first developed during the 1930's for use as lenses and prisms in ultra-violet optical systems, and, at the same period, fused quartz was first adopted for use in the manufacture of astronomical mirrors. The company now also produce articles in fused magnesia and alumina and in other high-temperature refractories.

DESIGNING RIGID STRUCTURES

APPLICATION OF THE PLASTIC THEORY

The development to date and the application of ultimate-load theories to building structures was the subject of a broad discussion at a Symposium held at Cambridge from September 18 *to* 21. *Over* 90 *visitors, including* 20 *from overseas attended, and they included engineers from consultants, government departments and the universities. The technical sessions were held in the Engineering Department of the University and centred about papers which had been published in the* British Welding Journal *for August*, 1956. *All the delegates were presumed to be conversant with the subject and no attempt was made to introduce the plastic theory to those unfamiliar with it.*

MULTI-BAY FRAMES

In welcoming the delegates to the conference Professor J. F. Baker demonstrated an autographic model which showed the behaviour to collapse of mild-steel beams and portal frames. The first technical session was concerned with the design of single-storey frames of the portal type. A great many portal-frame structures have been designed and erected on the basis of the plastic theory since the end of the war in Britain, and the problems relating to single-bay frames are now well understood. The paper presented by Dr. J. Heyman, and the discussion which followed, showed that the more urgent problems awaiting solution were those relating to multi-bay frames. In a series of pitched-frame portals, the rafter loading exerts a sideways thrust which, although self-balancing between the internal bays, has to be resisted in some way at the outer eaves level. Even when the frames are made sufficiently strong to withstand this thrust without any additional assistance, the problem of cumulative deflections may prove severe. One solution is to provide light ties between the eaves to take the thrust directly, but this solution was severely criticised on the grounds that it destroyed some of the advantages of rigid portal-frame construction, particularly that of an unobstructed capacity above eaves level.

It appeared that there was one aspect of multi-bay design which merited particular attention. It might at first sight seem that simple props would satisfy the essential requirements for the internal stanchions in such frames, but it was shown that dangerous conditions could occur due either to instability or unequal vertical loading unless rigid joints were adopted between the stanchions and the rafters at eaves level. Speaking generally, it would seem that no over-riding difficulties were to be expected in the design and fabrication of multi-bay portal frames, provided the requirement of joint rigidity was observed. A problem on which further information appeared to be necessary was that of the lateral instability of I-section members stressed beyond the elastic limit. Some work carried out at Cambridge on this subject was described by Dr. M. R. Horne, and more recent work completed at Lehigh University was described by Dr. R. L. Ketter. Dr. Ketter also gave particulars of work which had been done on local instability in members stressed beyond the elastic limit.

MULTI-STOREY FRAMES

The second session was concerned with the design of stanchions in multi-storey frames and was introduced by Dr. Horne. He reminded members that while a rigorous statement of the simple plastic theory of structures was based on the assumption of a rigid-plastic material, experimental work had shown that the basic theorems could be used for elastic/plastic frames over a wide range of practical conditions. These conditions represented the cases where deflections just prior to collapse were insufficient to upset the equations of equilibrium calculated for the undeformed state of the structure. When members carried high axial loads, the deformation prior to collapse could render the application of the plastic theory inappropriate. This situation was most likely to arise in multi-storey frames, and several solutions were suggested in order to overcome this difficulty. The problem was very much simplified if it could be assumed that sway deformation of a multi-storey frame was either of no significance for the collapse load of the structure, or was prevented by sway bracing or cladding. The methods presented for the design of stanchions assumed that these conditions operated. It appeared from the discussion that the conditions under which sway deformation could be ignored had not been sufficiently well defined, and the discussion on this point was carried further when frame stability was discussed at a later session. It was evident that, whereas the design of single-storey frames was an established procedure, the design of stanchions in no-sway frames was only just becoming possible. The problems of plastic design introduced by the possibility of overall sway of a multi-storey frame were evidently far removed from a satisfactory solution.

Professor J. B. B. Owen expressed the view that the attempt to design multi-storey frames which depended for their resistance to sway entirely on their behaviour as vertical Vierendeel girders was mistaken. The difficulties of the problem of frame instability revealed by the session on this subject, introduced by Dr. W. Merchant, would certainly give some support to this view. It was quite evident that this subject caused the greatest divergency of view between members present. While some progress had been made in the consideration of particular theoretical problems, the complexity of exact solutions described by Dr. R. H. Wood and Dr. K. G. Eickhoff appeared to rule out entirely the idea of arriving at conclusions of a general nature. A number of interesting empirical approaches were suggested, notably by Dr. Merchant, but although these were satisfactory over the range of experimental conditions which had been covered, the paucity of data on tests involving frame instability prevented any useful conclusions being drawn at this stage. The general feeling was certainly that more work needed to be done on this subject and this would evidently be necessary even if only to place a limit to the type of structures which can be designed without any special provision for resistance to sway. It was pointed out that existing design methods do not deal adequately with the sway problem and result in structures which really depend on the rigidity of the cladding for lateral rigidity.

MOMENT-RESISTING FOUNDATIONS

The design of rigid-jointed frames has thrown into prominence the necessity of obtaining foundations capable of withstanding turning moments in order to improve the resistance of such frames to wind loading. Results of some full-scale tests on portal frames with short pier foundations were presented by Mr. K. H. Roscoe and Mr. A. N. Schofield. In their discussion of these results, the authors sought to relate the behaviour of the foundations to that of the frame, and two types of footings for portal frames were considered, namely, short piers and slabs. These two types of foundations were suitable for differing conditions. The slab footing was suitable where moments were to be resisted, provided the vertical load did not fall below a certain critical value, but when a foundation could be subjected to a high bending moment with low vertical load, a pier foundation was necessary and could be very economical in use. It certainly appeared that the pier foundations used in the full-scale tests described would be unlikely to cost much more than a footing designed without moment resistance. The theoretical treatment of the pier-foundation problem

had been taken sufficiently far to enable practical design methods to be formulated. Great economy in foundation design could be achieved provided resistance to lateral motion at the top of the foundation was prevented by a tie or strut in the floor of the building. Differing opinions were expressed regarding the desirability of including such members in a floor.

THERMAL AND IMPACT STRESSES

Professor W. Prager presented a most elegant theoretical treatment of the effect of thermal stresses in an elastic/plastic structure. In a structure subjected to both cyclical variations of temperature and cyclical loading conditions sufficient to cause yield, plastic deformation would occur such that, if possible, the accompanying changes of stress and strain could take place elastically. If this were not possible, the structure would undergo a condition either of alternating plastic yield or of gradually increasing deflections due to progressive plastic deformation. The problem was thus closely analogous to that of the shake-down phenomena in the absence of thermal stresses—a subject which has been widely discussed in the literature.

The subject of dynamic loading and impact was introduced in a theoretical paper by Professor P. S. Symonds of Brown University and in a paper describing experiments on mild-steel beams and cantilevers presented by Dr. E. W. Parkes of Cambridge. The exact solution of dynamic problems in elastic/plastic structures is extremely complicated and both of these workers were interested in the extent to which simplifying assumptions could be made. The main assumptions concerned were the neglect of elastic response and the approximation that the yield stress is independent of the rate of strain. Both authors suggested that although there was a range of problems for which the simple rigid plastic analysis gave good results, problems in which extremely high and rapidly varying rates of strain occurred could not be solved satisfactorily by assuming a constant yield stress. In the discussion, Professor Hoppmann of the Johns Hopkins University, Baltimore, expressed doubts as to whether the elastic response of a structure could be neglected in a very wide range of problems. Dr. E. N. Fox of Cambridge, while agreeing that this was so, was of the opinion that simple approximations of the elastic response were adequate, adopting only the lower elastic modes of vibration, because of the damping of the higher modes. Professor Hoppmann, however, quoted examples in which the motion could not be satisfactorily explained unless up to 30 basic elastic modes of oscillation were included. It was evident from the discussion that problems varied enormously in the extent to which simplifying assumptions could be made, the general approach of the individual speakers depending on their particular experience. It was pointed out by Professor Baker that ideas based on a simple energy balance could lead to very close agreement in cases where the rate of loading was moderate. Thus in the design of the Morrison shelter, with which he had been associated, it was found possible to design the shelter on the basis of a stipulated deflection using the static collapse load as a measure of the resistance. A film was shown which illustrated the behaviour of surface shelters and a model was used to illustrate the capacity of a steel-table shelter to resist large impact energies by absorption in plastic deformation.

LIMITING DEFLECTIONS

The session devoted to a discussion of design problems revealed the wide diversity of interests represented by the members of the symposium. The comparative advantages of bolted joints designed to develop the full strength of the sections and of site welding were discussed. Particulars were given by Mr. R. T. Cole of the Conder Engineering Company of some of the structures which they had designed on the basis of the plastic theory, using haunched rafter-to-stanchion connections. Mr. Cole was of the opinion that practical considerations rendered site welding impracticable in the majority of cases. Other speakers, however, considered that site welding could be economic and should be encouraged. It was pointed out that where a joint of less than full strength was used, it was necessary for it to possess a high degree of rigidity and to be situated on a point in the structure where the maximum bending moment under any loading condition was within its capacity.

The opinion was expressed by Dr. D. A. Godfrey that deflections in structures designed by the plastic theory might prove larger than those experienced in similar structures designed elastically. There was some disagreement regarding the comparisons which should properly be made in discussing the relative deflections of structures designed by the two methods and it was evident that the main difficulty lay in the absence of any clear ideas of what limiting deflections ought to be allowed at working loads. Both orthodox design methods and methods based on plastic behaviour related design to the strength of a structure. In those cases where rigidity at working loads was of great significance, the design might have to be based on limiting deflections, irrespective of whether the design process used elastic or plastic theory as the basis of the initial calculations. If a structure were designed with rigid joints, first on the elastic theory and secondly on the plastic theory then, to the extent that the plastic design showed a greater economy in the sections used, it would necessarily have greater deflections than the elastic design. Where, however, the use of plastic theory in design encouraged the adoption of rigid joints in place of semi-rigid or non-rigid connections, the net result would quite commonly appear to be a reduction in the deflections at working loads. It was mentioned that, until considerable experience had been gained, the calculation of deflections was desirable in structures designed by the plastic theory.

The difficulties of purlin design due to the limited range of small rolled sections available in Britain were mentioned. If angle purlins were retained there was no overall advantage in economy by adopting main frame spacings greater than 12 to 15 ft. Some speakers also doubted the advantage of attempting to design purlins as continuous members because of the difficulty of erection. An alternative approach, in which small rolled I-sections were used for the purlins, was put forward. It was argued that the economy achieved by making these continuous was well worthwhile, although sag rods were required to take the component of the load acting down the rafters. The advantages possessed by broad-flange beams generally, compared with rolled I-sections, were mentioned. Dr. Ketter referred to a long series of tests performed at Lehigh University on the behaviour of broad-flange members in rigid frames, in which it had been shown that their behaviour in the plastic range was satisfactory.

TEACHING PROBLEMS

The final session of the symposium was concerned with the place which should be given to the plastic theory of structures in teaching. There was universal agreement that the plastic theory of structures ought to be included in University courses, but several speakers re-echoed remarks made by Professor Baker in his introduction, to the effect that there should be no net increase in the content of already overcrowded courses. The discussion showed that a clear distinction between the processes of structural analysis and those of design ought to be made. Whereas the plastic theory did offer a direct design process, a direct design method was not possible for many problems on the basis of elastic behaviour. The plastic theory could thus fulfil a most useful function in education by enabling the differences between analysis and design to be explained. It was at the same time pointed out that detailed design procedure could not be covered in undergraduate courses, and that only the basic conceptions of the plastic theory could be taught to undergraduates. In postgraduate courses, much more attention should be given to its difficulties and limitations.

The discussions throughout the conference revealed deep interest in the plastic theory as the basis of a design method for rigid frames. It was apparent that there existed a real understanding of the general principles involved, as also a healthy awareness of the difficulties which could arise in practical applications. The varying approaches of the members of the symposium proved stimulating and showed the advantage of bringing together those who were individually concerned with design, fabrication, teaching and research.

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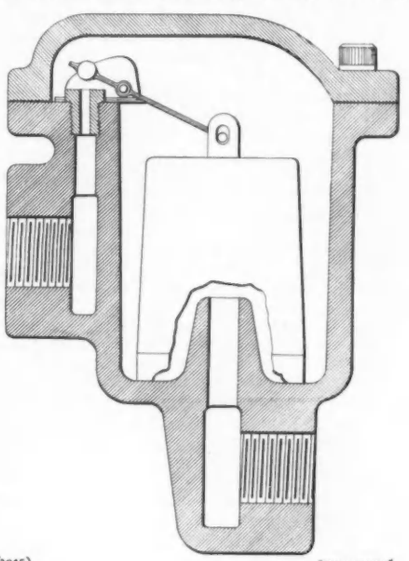
SMALL STEAM TRAP

Designed particularly for applications where a number of small inexpensive steam traps are required is a unit recently put on the market by Lancaster and Tonge, Limited, Pendleton, Manchester. At present it is made in 1 in. and ¾ in. sizes only, but a similar ½ in. size will be available later. The trap is of the inverted-bucket type with a double leverage action which enables large diameter seatings to be used and gives a large capacity-to-size ratio. The water discharge is copious and the float remains at the bottom of the box as long as water is entering



the trap; only when steam enters does the valve close.

A section of the trap is shown in the illustration. The inlet is at the bottom right, and when steam enters it displaces the water from inside the bucket float causing the latter to rise, which action in turn seals the outlet valve. In the top of the float is a small hole which allows the steam to escape when under pressure from a prolonged in-flow of condensate; as the steam escapes the float sinks and again opens the outlet. Water and air are continuously discharged from the trap. The body is made of cast iron and is suitable for pressures up to 200 lb. per sq. in. and all the internal fittings are made of stainless steel, except the float which is of copper.

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ELECTRIC TRACTION IN FRANCE

Electric traction on the 1,500 volt direct-current system was inaugurated on the line between Bellegarde and Geneva on September 27. In consequence, trains between Paris and Geneva and Lyons and Geneva are now being hauled electrically throughout their journey.

This inauguration represents a further step in the programme of railway electrification in south-east France. The next steps will be the conversion of the lines from Dijon to Vallorbe and between Lyons and Nimes via Avignon. The first of these should be completed by the end of 1957 and the second by 1961.

RUBBER IN ENGINEERING

FLEXIBLE, RESILIENT, NON-CATASTROPHIC IN FATIGUE

During the last 20 years the engineering possibilities of rubber have been extended by an increased understanding of its mechanical behaviour, and by improvements in mixing techniques developed by the rubber technologists. Rapid development of its applications have taken place, some of which are still unfamiliar to many engineers. To assist in making recent developments more widely known, the National Rubber Development Board recently held a one-day conference in London at which some of the aspects of rubber in engineering were discussed, on the basis of five written papers, each subject being introduced briefly by the author. We give below summaries of the written papers. A 16 mm. film illustrating "Rubber in Engineering," was also shown.

USING RUBBER CORRECTLY

The first theme to be discussed was "Rubber Must be Used Correctly," presented by Dr. W. J. S. Naunton, who said that rubber must be compounded, processed and vulcanised for the purpose in hand; it must be correctly designed for the unit in which it would function, and it must be used correctly during its life.

Discussing the design of engine mounts, Dr. Naunton said that, having defined the stiffness of the rubber required for the job, the rubber technologist then had to develop a rubber compound with the appropriate properties—hardness, hysteresis, compression set, heat resistance and oil protection. Although natural rubber could be protected against oil by an isocyanate varnish, such varnish would not withstand serious abrasion and in such cases an oil-resisting synthetic rubber, less resilient than natural rubber, must be employed.

Recent developments in rubber spring design were based on (1) the use of rubber as an air container and (2) for very high pressures, its use as a hydraulic fluid in a distortable steel container. An excellent example of the improvement which could be effected by a small change in design was the alteration of the square inner unit of the Neidhart system to one with curved surfaces (Fig. 1), allowing more rubber to be used in a given unit, with consequent increase in stored energy together with a more rapid development of resistance torque for a given angular deflection.

The design of O-rings, used widely for both static and dynamic seals, required a deep knowledge of rubber properties. They should fit the shaft by peripheral pressure, such as might be exerted by a second soft outer ring, rather than by tension.

The possibility of making gaskets by pouring a liquid rubber latex mix into a cavity and curing *in situ* deserved consideration. The weathering of rubber sealing strip or channel resulted from the action of atmospheric ozone; the mix should therefore be compounded with anti-ozonants, and the component should preferably be cured to shape, avoiding stretching and sharp corners both of which promoted ozone attack.

Correct compounding, processing and curing were of great importance for rubber linings for chemical plant, and also for use in water-lubricated rubber bearings to give the required resistance to abrasion combined with a low coefficient of friction to gunmetal. Rubber bearing units should be injection-moulded to eliminate the risk of ply separation after prolonged water immersion, and should be bonded to the metal packing by brass plating or a chemical bonding agent.

Discussing the use of components, Dr. Naunton said that rubber should not be subjected to heat, sunlight, ozone, oil and grease. Accelerated tests of rubber components should simulate service conditions so far as possible, and should be carried out under dynamic conditions. Bonding between rubber and metal could be tested non-destructively by ultrasonic testing or destructively by multiple impact or peeling. Shelf-aging tests were important. New techniques included the use of fine radio-active powders to measure quantitatively the cracking in weather strip.

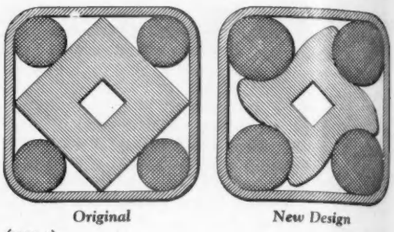


Fig. 1 By changing the square inner unit of the Neidhart suspension system to one of curved surfaces, larger and more effective rubber units can be employed in a given unit.

LOAD/DEFLECTION CURVES AND STRAIN DISTRIBUTIONS

Experimental measurements of the load/deflection relations for flat rubber pads in compression, and of the distribution of strain over the free surfaces of bonded rubber cylinders under compression and tension, were described by Dr. A. N. Gent, of the British Rubber Producers' Research Association, in his paper, "Load-Deflection Relations and Surface Strain Distributions for Flat Rubber Pads." He said that flat rubber pads of a range of thicknesses and of various cross-sections—square, rectangular, circular, and circular with a central hole—were compressed between steel plates. For small compressions, the load/deflection curves were reasonably linear and the apparent Young's Modulus E for each specimen could be deduced

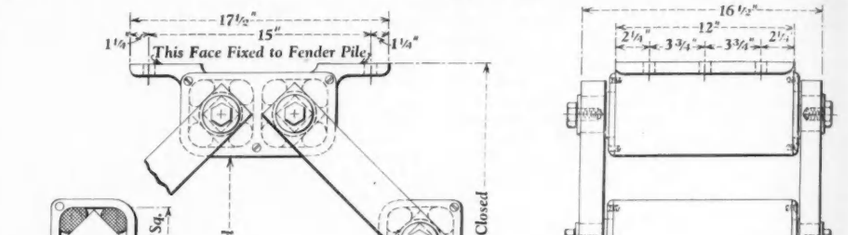


Fig. 2

Figs. 2, 3 and 4 The André Neidhart dockside fender unit.

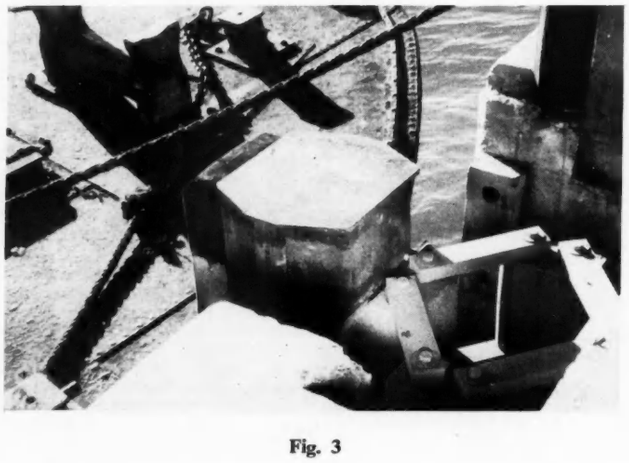


Fig. 3

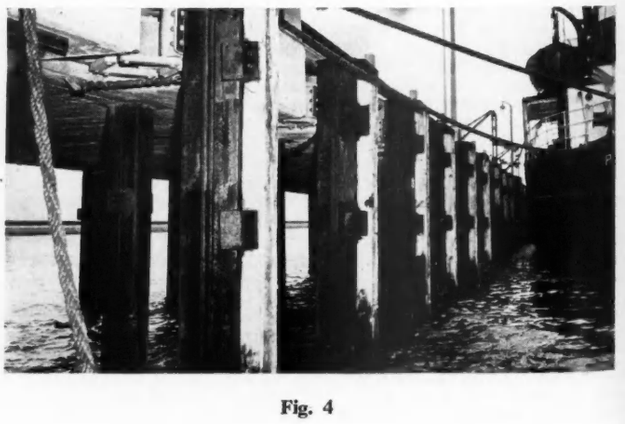


Fig. 4

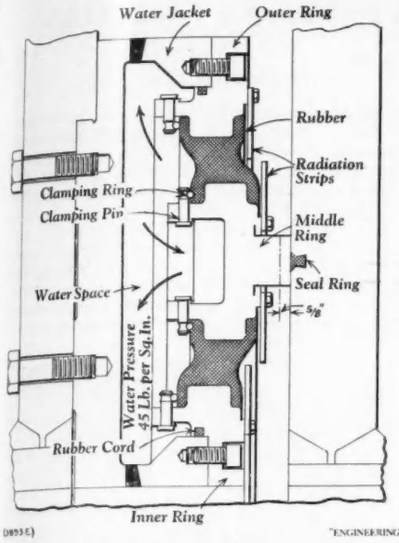


Fig. 5 Section through the main-casing rubber-bonded-to-metal seal for the R.A.E. supersonic wind tunnel, Bedford.

Plotted against F, the shape factor, for the specimen—i.e., the ratio of the area of one loaded surface to the force-free surface—the points for all the specimens fell within close limits, on a single curve. This curve could be derived from the relations

$$\frac{I}{E} = \frac{1}{E_F} + \frac{1}{E_\infty}$$

where E_∞ was the modulus of bulk compression, and E_F was given by the equation

$$E_F = E_0 (1 + AF^2),$$

E_0 being the "real" Young's Modulus and A a dimensionless constant.

Under relatively large compressions, the stress/strain curves for individual specimens were found to follow the relationship

$$\sigma = \frac{E(\lambda^{-2} - \lambda)}{3},$$

σ being the compressive stress, λ the ratio of the compressed thickness to the original thickness, and E the apparent Young's Modulus governing small compressions.

In the other series of tests on surface strain distribution on cylindrical bonded specimens, ink marks of known dimensions were imprinted on the deformed surface of the specimen and were measured after relaxing the load, the values of the maximum and minimum extension ratios in the plane of the surface then being deduced. In the case of cylindrical specimens subjected to tension, it was found that if the metal end pieces to which the rubber was bonded were made of plug form instead of having plane surfaces, the surface strain in the neighbourhood of the bonded stress was considerably lowered.

HEAVY ENGINEERING

The growing applications of rubber in ships and jetties, in general engineering and buildings, for couplings, and in railway engineering were described in the paper on "The Use of Rubber in Heavy Engineering" by Mr. S. W. Marsh, of the André Rubber Company, Limited. He said that in ships, rubber flexible mountings had been extensively applied to auxiliary machinery but not much to main propulsion units. A recent innovation was the development of a rubber expansion joint to replace the fatigue-prone copper U-pieces conventionally employed in the main circulating-water systems on naval ships. Now becoming standard equipment, this joint was of synthetic rubber reinforced with nylon fabric, operated at a normal pressure of 15 lb. per sq. in., and was afforded flame protection by a fire guard.

The recent development of properly designed resilient fender units for jetties had made it possible to lighten and cheapen jetty structures. Mr. Marsh cited two types, one operating in direct shear, consisting of two plates with a sandwich of rubber bonded to each plate; and the other, the André-Neidhart type, employing rubber in rolling compression. The fender unit, as shown in Figs. 2, 3 and 4, consisted of eight rubber assemblies connected by lever arms. The single unit could rotate through 45 deg. This type of unit produced an exponential load/deflection curve, and was therefore suitable for arresting both small and large vessels.

An interesting heavy-engineering application of rubber was the bonded rubber-to-metal seal for the supersonic wind tunnel at the Royal Aircraft Establishment, Bedford. In this tunnel, driven by a ten-stage axial-flow compressor, the six rear stages could be removed as a unit for working at lower pressures and replaced by a cylindrical shell. Retractable seals were required between the movable and fixed portions of the tunnel circuit, these seals also accommodating thermal expansion. The seals, 18 ft. 6 in. in diameter, are illustrated in Fig. 5. They were fixed to the tunnel shell and the outlet end of the low-pressure compressor, and when the removable sections were brought in the seal was effected by building up pressure in the water box, putting the rubber units into shear and forcing the face of the inner metal part to seal on a rubber sealing ring. This was believed to be the largest rubber-to-metal bonded unit yet produced; the bonding under pressure and heat was carried out on site in a specially designed mould.

In structural engineering, the development of resilient rubber springs had overcome serious industrial vibration problems such as the mounting of forging hammers, rolling mills, ore crushers, etc. Such rubber springs were cheaper and had a longer life than helical or leaf springs. It was now a practicable proposition to insulate large buildings from existing ground vibrations by means of rubber sandwich springs.

Resilient couplings in rubber were now suitable for transmitting power for heavy machinery. Mr. Marsh cited as examples three types of rubber coupling—the Blackstone shear-type coupling, incorporating a large capacity viscous-fluid torsional damper in conjunction with a highly flexible coupling, for smoothing out torque fluctuations and vibrations in main power-transmission shafts; the André-Neidhart coupling acting in rolling compression, which could be incorporated in the main parts of the machinery, such as flywheels, etc.; and rubber-bush couplings widely used on vehicle propeller shafts to allow for relative movements between engine, chassis and rear axle. In test-bed equipment, particularly where misalignment and vibration could be severe, rubber flexible couplings were often superior to mechanical joints.

In railway engineering, there was a trend towards the use of rubber as a complete bogie

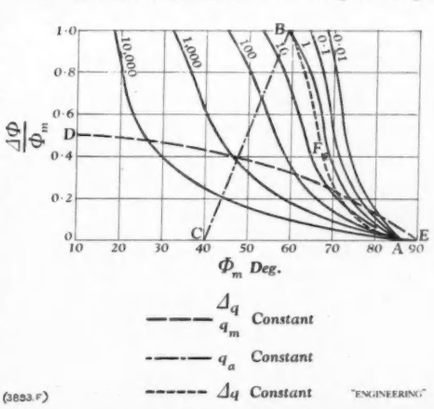


Fig. 6 Curves of fatigue life for rubber springs. Φ_m is the maximum angular strain at a given point in the component and $\Delta\Phi$ is the difference between maximum and minimum angular strain. The figures on the curves are in millions of cycles.

suspension system. Such bogies would give an improved ride, be much quieter and would tend to reduce flange and wheel wear. (A description of a rubber-suspended bogie developed by George Spencer, Moulton and Company, Limited for London Transport, and installed on a Piccadilly Line driving motor car, was given in the October 5 issue of ENGINEERING, page 440.) Other applications of rubber on railway stock included the pre-stretched form of rubber bushing for swing-link suspension, for the nose suspension of motors, and in resilient gearing.

FATIGUE LIFE

Fatigue tests undertaken to establish the way in which loading conditions and design changes may affect the fatigue life of dynamically-loaded rubber components such as engine mountings and springs were discussed in a paper on "Dynamic Fatigue Life of Rubber Components," presented by Mr. P. W. Turner, of George Spencer, Moulton and Company, Limited. For spring-type rubbers with shear moduli between 70 and 110 lb. per sq. in., fatigue life, he said, was predominantly a function of the strain in the rubber body, and such factors as temperature, vibration frequency, and rate of change of strain could usually be ignored.

If Φ_M were the maximum angular strain at a given point in the rubber, and $\Delta\Phi$ the difference between maximum and minimum angular strain, then if $\frac{\Delta\Phi}{\Phi_M}$ were plotted against Φ_M, a family of curves each representing a given number of cycles to failure was obtained, as in Fig. 6.

There were three kinds of design changes or operating conditions particularly relevant to rubber springs and mountings:—

(1) The mean load on the component might remain constant while the amplitude of excitation was changed. This was represented in Fig. 6 by the line BC, which showed that fatigue life was sensitive to the displacement amplitude.

(2) The ratio of dynamic load to mean load might remain constant, as when components of differing size, but having equal rates, were considered in order to determine the greatest stress which could be employed for a given application consistent with adequate life. The line DE in Fig. 6 represented the conditions of strain and, since in a component with a non-uniform stress distribution the ratio of change in stress to maximum stress remained substantially constant throughout the body, the line DE represented the dynamic fatigue conditions in the rubber of such a component, and illustrated the importance of ensuring uniform stressing if maximum endurance were required from a minimum volume of rubber.

(3) The effect of changing the mean displacement of the component, other factors remaining unchanged, was represented by the line BE. An example was a vehicle carrying differing loads, the wheel stroke remaining unchanged. Over the usual working range the fatigue life increased as the load and stress increased and, other things being equal (in practice they were not), the fully-laden vehicle would have the longer spring life.

Usually, however, the fatigue life of a component was determined by local areas of high strain, and Mr. Turner described a photoelastic technique for determining non-uniform strain distribution on rubber components which had proved useful for determining strain in irregular-shaped and complex components.

A valuable property of the rubber spring was that fatigue failure was always progressive and never catastrophically sudden. The criterion of failure, therefore, was arbitrary and in the tests described was taken as a 10 per cent. reduction in rate.

RUBBER IN AGRICULTURE

Typical examples of successful applications of "Rubber in Agriculture" were described in the paper by Mr. S. J. Wright, of the Ford Motor Company, Limited, Dagenham, Essex, who contended that the more successful new types of agricultural machinery were all based on

Fig. 7 Stanhay drill units for metering sugar beet seed.

Fig. 8 Spool-type potato sorter.

rubber. By industrial standards, the farm machine had to be " unreasonably " cheap, and it was more important for it to be convenient and effective than to be technically efficient. For instance, the pneumatic-tyred tractor had now come into almost universal use because of its convenience on farms which were very much intersected by hard roads. With pneumatic tyres, there was no reason why plough bodies should not be redesigned for speeds of 5 to 6 m.p.h., a step which would solve most existing problems of weight and stability. The development of the rubber-jointed track, in which wear at high speed was greatly reduced, pointed the way to economically feasible tracked power for everyday farming.

Discussing cultivation, Mr. Wright cited the rubber harrow developed in the 1930's, by Dr. G. H. Bates, which was successful in eliminating weeds and coarse grasses from pastures; and the Rotoflail, which used canvas and rubber flails rotating on a horizontal shaft to disintegrate unwanted vegetation.

In sowing, a notable development was the Stanhay drill unit (Fig. 7) which gained the only award in the 1953 trials of the British Sugar Corporation for eliminating the handwork of singling sugar beet. The metering mechanism was a thin rubber band pierced regularly with holes and running on two flat rimmed wheels. Each hole in turn metered one seed and took it to the discharge point where it fell into the seed furrow.

For forage harvesting, two striking new applications of rubber belts were the American Allis Chalmers Roto Baler in which the forming, tying and ejection processes were completely automatic; and the British Wilder-Steed forage harvester, an elevator-type hay or green-crop loader specially adapted to one-man operation at high travelling speed.

The modern milking machine, by virtue of the soft natural rubber lining of the teat-cup, simulated the action of the calf's mouth much more closely than did handmilking, applying a process of intermittent suction and squeezing.

The improved potato sorter (Fig. 8), in which side-by-side rotating rubber spools replaced conventional wire-mesh riddles, had a much higher throughput than the older type of machine since the action of the spools assists in aligning the tubers to the optimum position for getting through. Potato harvesting was a particularly good example of the discriminating sorting problem—separating stones from potatoes—in which rubber was likely to play an increasing part Citing different approaches to this problem, Mr. Wright mentioned a Swedish machine employing three slotted sheet-rubber riddles in which the tilt, amplitude of oscillation and stretch of the rubber could all be varied, allowed a freer passage to the denser stones; and the Packman harvester which employed a "separation carpet"—a sloping conveyor faced with closely set rubber fingers in which stones, clods, and debris tended to get caught and carried along. The elimination of hand labour was still not yet in sight.

In conclusion, Mr. Wright pointed out that the virtues of rubber for agricultural applications depended largely on its "flexibility" in the widest sense—flexibility of application as well as of movement, which could make stones behave differently from potatoes and rendered agricultural rubber components self-cleaning.

* * *

FILM ON RUBBER IN ENGINEERING

The 16 mm. half-hour sound film entitled "Rubber in Engineering" mentioned above is available on loan from Sound Services Limited, 269 Kingston-road, London, S.W.19, and prints may be purchased if desired.

The film is in the nature of a general introduction to the subject. Stress is laid on recent scientific investigations into the physical properties of rubber which has placed a fund of comprehensive data at the service of the designer.

The final sequences consist of a number of short practical "stories" showing the use of rubber anti-vibration mountings in a factory where delicate precision work is carried out, the recent installation of rubber rail pads on Southend Pier to reduce noise in the Pavilion, the use of rubber in dockside fender installations and the performance of the all-rubber front and rear suspensions in a new omnibus.

PORTABLE HYDRAULIC POWER KIT

Interchangeable Rams

A range of portable hydraulic power kits manufactured under licence from the Blackhawk Manufacturing Company, Milwaukee, U.S.A., by E. P. Barrus (Concessionnaires) Limited, Acton, London, W.3, is now available in the United Kingdom. Known as Porto-Power, the main unit comprises a ram and hydraulic hand pump connected by a steel-cored reinforced hose; a variety of attachments can be supplied for specific purposes, such as pipe-bending attachments and pulling attachments for removing pulleys and gear as well as for general maintenance. It is available in capacities from 8,000 lb. to 100,000 lb.

Porto-Power units, comprising two 40,000 lb. rams and hand pumps, are used at Scottish Aviation Limited for stretchforming airframe panels.

Quickly interchangeable rams range in size from $\frac{5}{8}$ in. stroke, with a collapsed height of $1\frac{13}{16}$ in., to 5 in. stroke, with a collapsed height of 11 in. One pump can, if desired, operate several rams simultaneously. The equipment is so compact that the largest kit, including four interchangeable rams, will fit into a case measuring 36 in. by 18 in. by 18 in.

The accompanying illustration shows Porto-Power units used for stretch-forming aircraft fuselage and wing panels at Scottish Aviation Limited, Prestwick. Two 40,000 lb. rams are employed, each actuated by a hand pump equipped with a pressure gauge.

* * *

TESTING FUEL TANKS FOR LEAKS

The Boeing Airplane Company, Seattle, Washington, U.S.A., have developed a new method for detecting leaks in fuel tanks undergoing pressure tests. A chemical coating, bright yellow in colour, is sprayed or brushed on to the outside of the tank. A small proportion of a special gas is mixed with the air used to pressure-test the tank. Should this gas leak through the wall and come into contact with the chemical coating on the outside of the tank, the coating at that point turns purple. After the test is completed, the coating can be removed from the tank by blowing with an air hose, wiping off with a cloth, or washing off with a stream of water. Similarly, if tested with liquid instead of air, the chemical can be added to the liquid in the tank.

SUPPLYING POWER TO MOVING PARTS

FLEXIBLE GUIDES FOR CABLES AND HOSES

Connections for electric power, gas, compressed air, or liquid under pressure for hydraulic purposes, from a fixed point to a moving part of a machine, take several forms, each of which has its disadvantages. For electricity, sliding contacts or pick-up wires are a very common solution to the problem, but neither can be used in an explosive atmosphere as they may be a source of danger to persons working in the vicinity. They also suffer from the effects of dirt, dust and corrosive fumes. Gases and liquids, whether under pressure or not, must of course be conveyed in flexible hoses, which may be subject to mechanical stresses and are liable to damage by crushing or other accident. Flexible cables for electric power, a common alternative to contacts, are subject to the same disadvantages as hoses.

The method of guiding cables, hoses, or both, which is shown in the accompanying illustrations, has none of the disadvantages of free trailing cables or hoses. It has been designed by Kabelschlepp, G.m.b.H., Siegen, Germany, and is available in Great Britain from Mr. Fred Senior, Bourton, Rugby, Warwickshire, the sole agent for the manufacturers. The Kabelschleppkette, or cable drag chain consists, briefly, of steel links pivoted to each other, and having cross-stays in which the cables or hoses are carried. The flexible members conveying power are not subjected to tension, compression or torsion stresses, and the amount of bending is controlled to a fixed minimum radius by the guide chain. In hydraulics this latter feature is of particular value as it ensures constant pressure in the hose.

ADAPTABILITY

The side links of the chain are hot-forged from high-quality steel, machined, and pivoted on hardened steel bushes; these are secured against lateral movement by means of rivets and washers. The stays are of cast aluminium corrosion-resisting alloy, and they can be extended according to the number of power lines carried. They can also be supplied in dismantled condition, to facilitate the insertion of the cables or hoses into the chain. Fig. 1 gives a general view of the chain, which is shown, in this instance, carrying four sets of cable and a hose.

One end of the chain is fixed to the base of the machine, the framework, or the floor, by means of a terminal point, and the other is attached to the moving part of the machine by a similar terminal. If necessary, two chains can be used on one machine, extending in opposite directions from their terminal points. In this case the supply capacity is doubled, and as both chains run in the same track, no extra space is required. As the moving part of the machine travels, the cables and hoses are raised with the chain off the floor, or returned evenly to the support track, according to the direction of travel. Fig. 2 shows a typical application of the chain, and illustrates clearly the way in which it supports the lines of cable.

The chain bends in one direction only, at a radius pre-determined by the taper of the individual links on the "inside" of the bend. The ends of the links on the opposite side of the chain are square, and rest against each other to give rigidity to the assembly and to prevent the top run of chain from collapsing. The tapered and square ends of the links can be seen at the bottom and top respectively of the chain shown in Fig. 1. When the moving part of the machine is in motion the individual chain links are stationary relative to each other until they go over successively from the straight line to the curve. The links then swivel at approximately 30 deg., the movement taking place slowly even if the machine carriage is travelling rapidly. As a result of the restricted movement of the chain, wear is negligible.

RANGE OF SIZES

The radius of curvature can be varied to suit individual requirements, and several sizes are made. In the smaller sizes the chains have a radius of curvature of 50 to 125 mm. (2 to 5 in.), while the standard type has a radius of 145 mm. (5¾ in.). These chains are suitable for use with unsupported suspended runs of up to 5 metres (16 ft.), the total movement of the travelling carriage being, in this case, 10 metres (32 ft.). Fig. 3 shows an application of the chain to an external cylindrical grinding machine which has a long carriage travel and a chain with the top run unsupported. It is possible to have runs longer than 10 metres without top run support, but strengthened chains are then supplied.

For runs up to about 20 metres (66 ft.) rollers are used to support the chains, and for long runs, from 20 to 200 metres (66 to 656 ft.), more elaborate supporting systems are employed. These include caged ball rollers attached at intervals to the chain, which travels in a totally-enclosed channel, and so-called chain carriages. These are interconnected trains of wheels supporting the entire upper run of two chains, which in such an arrangement extend from the moving part of the machine in two directions, the combined length of the upper runs being always the same. The heaviest type of cable drag equipment is the cable carriage supporting cables on a train of coupled wheels while the pulling stresses are taken by a wire rope arranged alongside the cables.

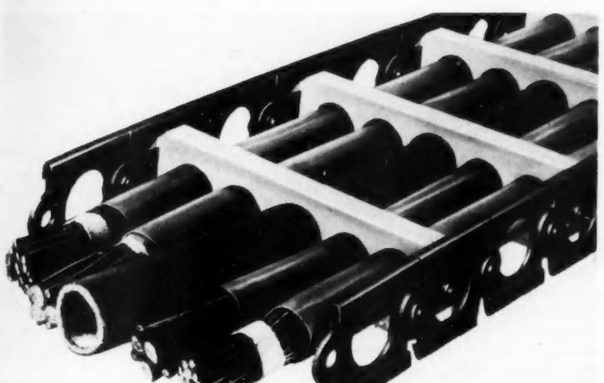


Fig. 1 Cables and hoses are guided and kept free from external stresses by the cable drag chain.

* * *

STERILISED AIR

Portable Irradiation Unit

For those places where it is desirable to have sterilised air, as in surgeries or at food counters, an irradiation apparatus has been developed by Penfold and Partners, 120–122 Victoria-street, London, S.W.1. Within the unit, a fan draws in air at the rate of 350 cub. ft. per minute and passes it over the irradiation tubes which operate at 2,537 Å. At this wavelength, the cell structure of micro-organisms is attacked and broken down, so that germ-free air is returned to the room. The fan is mounted in a spider, and is silent in operation. When working, the fan and tubes consume 55 watts and are capable of continuous operation, drawing their supply from the standard mains. The case, which has a rounded cover, measures 3 ft. long by 9 in. high by 8 in. wide and is equipped with a carrying handle.

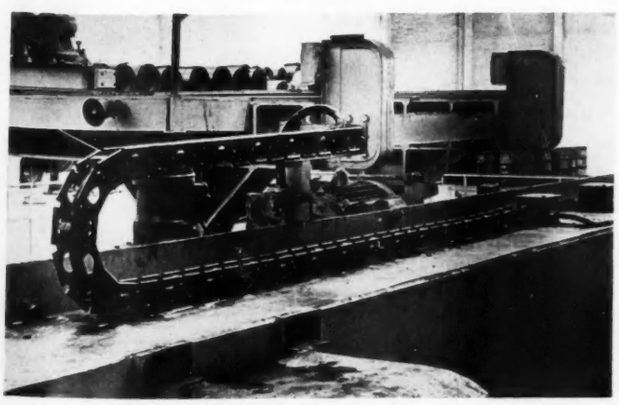


Fig. 2 One end of the chain is fixed to the stationary part and the other to the moving part of the machine. The chain bend radius is constant.

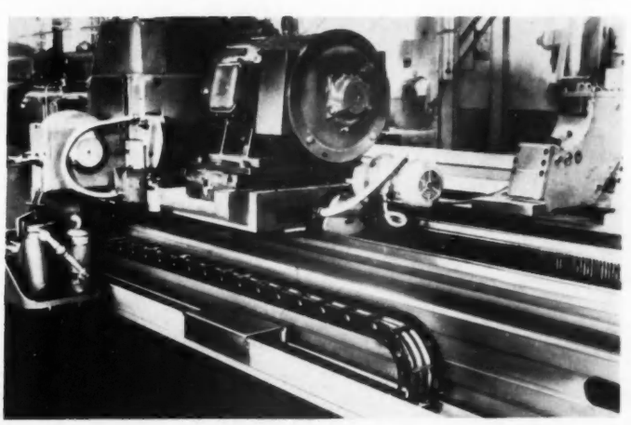


Fig. 3 This typical application to a machine tool shows the compact arrangement, and the relatively long unsupported top run of chain.

CALDER HALL SERVICES RENDERED

The nuclear power station at Calder Hall is the result of an immense co-operative effort. Almost from its conception engineering firms have taken part in the project, and their contribution has not been simply to produce standard or specified items, they have also carried out much of the development work made necessary by its novel character. In the final article in our current series on Calder Hall, which commences this week, we draw attention to the part played by contractors and sub-contractors, but begin by briefly outlining the history and origins of the project. Reference has already been made to some of the engineering firms concerned in a previous article, which appeared on page 469 of our issue of October 12 and dealt with problems of engineering design and construction; an introductory article was published on October 5 (page 418).

Fig. 1 The construction of Calder Hall " B " on an adjacent site to the " A " station is well under way. This view from the biological shield of the " B " station's No. 1 reactor, shows, in the foreground, the foundations and partially completed turbine plinths of the turbine hall, the foundations of No. 2 reactor, and one of the newly completed cooling towers.

History and Origins

In 1950 Mr. R. V. Moore, who is now the United Kingdom Atomic Energy Authority's chief engineer for thermal reactor design, prepared a paper on the cost of electricity obtained from a thermal nuclear power station, giving an estimated figure of one penny per unit. Following discussions on the paper, Sir John Cockcroft set up a small team to investigate the possibility of designing a plant to produce electricity and plutonium from a reactor using natural uranium as fuel. Considerable experience was already available, for GLEEP (Graphite Low Energy Experimental Pile) had been in operation at Harwell since 1947 and BEPO (British Experimental Pile O) since 1948. The Atomic Energy Research Establishment at Harwell had itself been founded in 1946. Further knowledge was accumulated in the design and construction of the Windscale plutonium-producing piles, which like the Calder Hall reactors are graphite moderated. In addition developments in other fields were taking place which would eventually meet the needs of the Calder Hall station: as long ago as 1948, for example, Babcock and Wilcox Limited had begun to study the dual-pressure cycle which was later to be used in the Calder Hall heat exchangers, and work on a vertical spinning tunnel for what was then the National Aeronautical Establishment, in conjunction with the Ministry of Works, gave Whessoe Limited experience which subsequently assisted in the design of the reactor pressure vessels.

The Ministries of Works and Supply have also played a part in the growth of Britain's atomic energy programme, which has now culminated in the world's first full-scale nuclear power station. From 1945 until August, 1954, when the U.K.A.E.A. was formed, the Ministry of Works co-operated with the Ministry of Supply Atomic Energy Division in the building and equipping of the various atomic energy establishments, and since 1954 has rendered similar assistance to the Authority.

In 1946, a Ministry of Supply establishment responsible for the construction of the atomic energy factories was set up at Risley under the direction of Sir Christopher Hinton. A strong M.O.W. section, including architects and mechanical, civil, structural, electrical and sanitary engineers, was seconded to Risley and worked in close liaison with M.O.S. design staff on various projects, including the Calder Hall power station. The M.O.W. staff were generally responsible for all works and buildings, including site construction and the letting of the building and civil engineering contracts. This arrangement continued until August, 1954, when the U.K.A.E.A. absorbed the M.O.S. and M.O.W. staff who wished to stay with them.

The 1951-52 design study for a gas-cooled, natural uranium power reactor had by the spring of 1952 been developed to the stage when the A.E.R.E., Harwell, were able to bring in and seek advice from the British Electricity Authority (now C.E.A.), the M.O.W. and a number of specialist firms. The work of these organisations was co-ordinated by A.E.R.E. through the Plant Co-ordinating Committee set up in April, 1952. The M.O.W. were responsible for building services and prepared the one-eighth inch scale architectural and structural drawings, together with the capital cost statement for this work. With the B.E.A. and A.E.R.E. they prepared a preliminary construction programme.

When the Thermal Reactor Design Office was opened at Risley in April, 1953, the M.O.W. contributed a section working under the direction of the chief engineer of the project. This arrangement continued until August, 1954, though certain staff continued on the project, after that date. The team was principally engaged on the co-ordination of design work and construction with the pressure-vessel contractors and in the design of the thermal-shield cooling system. In accordance with previous practice the M.O.W. supplied the main construction team, whose work was co-ordinated with that of the design office through monthly site meetings at Calder Hall.

Construction

Last week we described in some detail the scope of the building work on the Calder Hall

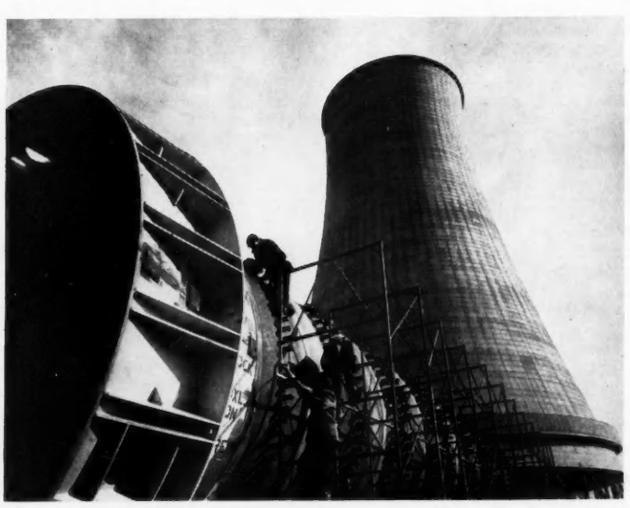


Fig. 2 One of the Calder Hall " A " 300 ft. cooling towers, with a heat exchanger in the foreground already assembled on site ready for erection.

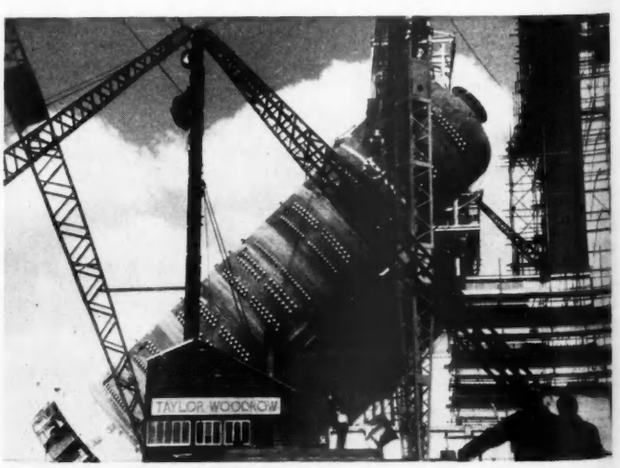


Fig. 3 Lifting the heat exchangers into position was a major task involving 100 ton gin poles, three Diesel winches, a crane and radio communication.

"A" station undertaken by *Taylor Woodrow Construction Limited*, and also referred to that now in progress on Calder Hall "B." This station is identical with Calder Hall "A," and a view of the site appears in Fig. 1. Some further details of the work may be of interest. The 130 ft. by 107 ft. by 11 ft. concrete rafts on which the reactors of station "A" are based were constructed in four lifts or layers, with each lift divided into 21 bays. Alternate bay construction was adopted and a period of three days allowed for shrinkage between the concreting of adjacent bays. The concrete for the walls of the 7 ft. thick 90 ft. high biological shields was poured in 20 lifts, each of 4½ ft. Spider scaffolding formed from 6 ft. cubes of steel angle bars and erected inside the shield ensured that the wooden forms against which the concrete was poured were set with the high accuracy specified—within ±0·1 in. Plumb-line accuracy was also of first importance since the 20 ft. long vertical fuel charging tubes could not depart more than $\frac{1}{16}$ in. from the vertical. The high density concrete required for the shielding (150 lb. per cub. ft. minimum, 162 lb. per cub. ft. achieved) was made with Northumberland Whinstone, which has a specific gravity of 2·9, and a detergent was used to help the flow. The turbine hall has a structural steel framework with asbestos cement cladding and patent glazing; the roof is patent steel decking covered with three layers of bitumen felt, the cladding being supported at points closer than normal as a protection against west-coast winds. An interesting departure from standard practice was the concreting of each of the four identical turbine blocks (175 cub. yds. at the steam and 125 cub. yds. at the alternator end) in one lift, an achievement made possible by accurate shuttering and telephone communication. For the 300 ft. cooling towers, one of which is shown in Fig. 2, an internal scaffold of pre-fabricated steel was used, and concreting was carried out in 3 ft. lifts.

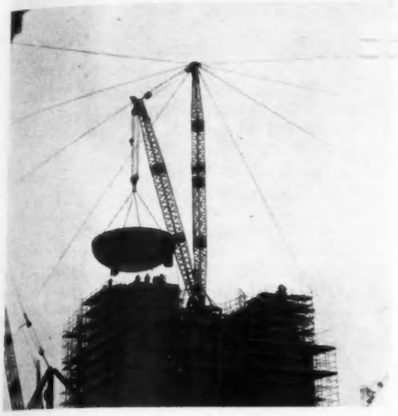


Fig. 4 Base of reactor pressure vessel being transferred into its housing prior to final welding.

Fig. 5 Top of pressure vessel during construction of the plant, showing blanked-off charging tubes. A serious problem in designing and building the 2 in. thick reactor pressure vessels was to secure adequate strength in spite of innumerable holes.

One of the major problems of construction was the lifting of heavy items such as the pressure vessels and heat exchangers into position. Fig. 3 shows one of the eight 80 ft. high, 17½ ft. in diameter, 178 ton heat-exchanger shells being raised prior to seating on its 16 ft. concrete platform. Final location of the heat exchanger had to be to within $\frac{1}{8}$ in. This unusual and delicate lifting operation was carried out by engineers from the Constructional Division of *Costain—John Brown Limited*. After fabrication on site the heat-exchanger vessels were fitted with a 15 ton steel collar, bringing the total load to 200 tons, and hoisted between two steel gin poles each 102 ft. high. Believed to be the largest lift yet undertaken in this country using wire rope and tackle, it was accomplished by means of three Diesel winches together with a crane. Since visual instruction was often impossible, radio links were employed. On arrival at the site, the vessel was manoeuvered to line up with the gin poles and the centre of the concrete plinth. A standing-way of 12 in. by 12 in. timber was built lengthways under the vessel, the bottom end of which was supported on a timber sledge. This was greased on its lower side to help it slide along the standing-way as the vessel was moved forward. A 30 ton "deadman" was set behind the vessel to act as a check while the vessel was moving forward towards the plinth. This operation was controlled by an 802 Lima crane, which moved slowly along the road slackening the tackle. When the vessel was fully suspended, the end on which the 25 ft. diameter skirt ring was fitted, was held clear of the foundations until it was above the surface of the base. It was then slacked in so that it hung suspended above the bolt holes. The foundation bolts were then inserted and the vessel lowered and bolted down. The lift was completed in two hours.

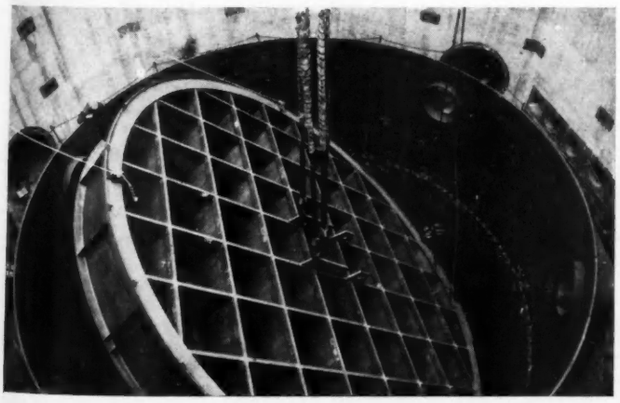


Fig. 6 The design of the diagrid which supports the graphite moderator inside the pressure vessel involved the solution of 35 simultaneous equations.

Pressure Vessels

We have already discussed at length the design and fabrication of the pressure vessels, which were made by *Whessoe Limited*. The problems involved included designing a vessel with innumerable holes to take a gas pressure of 100 lb. per sq. in., welding on site 2 in. thick steel plates, supporting the vessel in such a way as to accommodate thermal expansion without lateral movement, stress relieving and pressure testing. The latter was carried out pneumatically, using the reactor shielding as protection in case of rupture, since hydraulic testing might have entailed too great a load on the supports. Part of a pressure vessel is shown being lifted into the reactor housing in Fig. 4 and in Fig. 5 the top of a vessel is seen before construction of the charging floor. Another problem tackled by Whessoe Limited was the design and construction of the diagrid illustrated in Fig. 5, which supports the graphite moderator. To determine the dimensions of the component beams it was necessary to solve 35 differential equations.

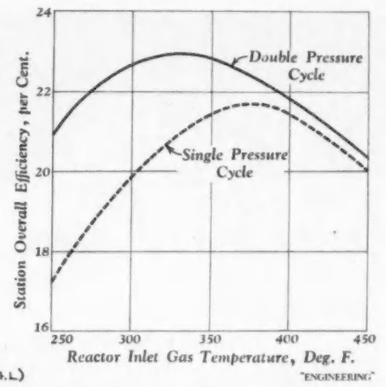


Fig. 7 Station efficiency for gas-cooled reactor. The dual-pressure steam cycle gives higher efficiency than the single-pressure cycle and permits a greater coolant temperature rise in the reactor without high outlet temperatures.

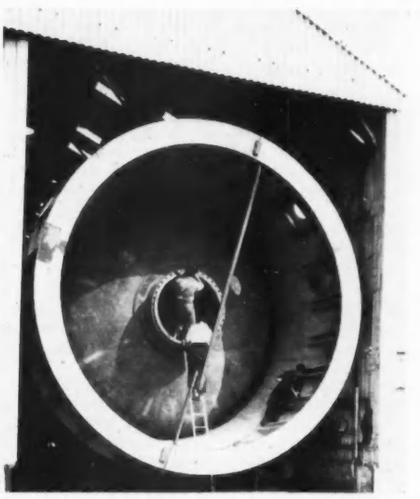


Fig. 8 Base section of a heat exchanger. Each heat exchanger was transported from the factory in 9 sections and welded together on site.

Heat Exchangers

Although many of the problems relating to the construction of the heat exchangers were concerned with fabrication, there was also the question of operating cycles to consider. *Babcock and Wilcox Limited* had undertaken work on this subject in 1948, and the system chosen for Calder Hall was the dual-pressure cycle. Fig. 7 shows the overall efficiency attainable with this cycle and also that of the simple single-pressure cycle for comparison. In the dual-pressure cycle part of the coolant-gas heat drop is used to generate steam at high pressure, and low-pressure

Fig. 9 Welding thermal sleeves on a section of a heat exchanger. To avoid contact between the steam and the carbon dioxide coolant, the heat exchangers were so designed that should a leak occur, escape would be to atmosphere. Contamination of the coolant would affect reactor operation.

Fig. 10 Steel fins of aerofoil section were electrically welded to the heat-exchanger tubes to provide extended surface for heat transfer.

steam is produced by the remaining heat. The turbines would then be designed to use steam in both conditions. The arrangement of the Calder Hall heat exchangers to accord with this principle was illustrated last week. From Fig. 7 it can be seen that for the Calder Hall reactors, where the gas inlet temperature lies between 250 and 300 deg. F., the dual-pressure cycle gives a considerable advantage in efficiency.

The high efficiency at these low inlet temperatures is particularly important in view of the dual purpose of the reactors—plutonium production and power generation. For a given investment of uranium and graphite, a higher temperature rise across the reactor allows its thermal rating to be increased; but a higher temperature rise means either that the reactor outlet gas temperature must be increased (which might not be permissible owing to considerations of fuel-element temperature) or that the reactor inlet gas temperature must be decreased. The dual-pressure steam cycle allows the second choice to be adopted giving an optimum result for both power and plutonium.

The double-pressure steam cycle employs a high-pressure boiler and a low-pressure boiler arranged in series with respect to the coolant. About 65 per cent. of the total steam is generated at the higher pressure and 35 per cent. at the lower. The high-pressure steam is led to the governor valve of the steam turbine and the low-pressure steam to an appropriate stage in the turbine flow. Both high and low pressure steam can be superheated with economy to within 30 deg. F. of the reactor outlet gas temperature. A typical example of steam conditions to meet reactor inlet and outlet gas temperatures of 300 deg. F. and 650 deg. F., respectively, would be 65 per cent. of the total steam at 400 lb. per sq. in. and 620 deg. F., and 35 per cent. at 100 lb. per sq. in. and 620 deg. F. It is not generally realised that a gas-cooled graphite-moderated reactor operating with gas temperatures of 450 and 650 deg. F. can produce high-pressure steam at nearly 900 lb. per sq. in. and low-pressure steam at 500 lb. per sq. in., again in the proportions 65 to 35. Such conditions would not be used for power generation because the overall efficiency would be below the optimum value, but may conceivably be suitable for other purposes.

The design of heat exchangers based on the dual-pressure cycle was one of the major tasks undertaken by Babcock and Wilcox, Limited, and the details given above have been taken from a paper by Mr. W. R. Wootton, who is now the assistant manager of that company's Atomic Energy Department. Once the basic design had been evolved, the company were then faced with some unusual construction problems; some of these were discussed last week. However, with their experience in the field of heat exchange and the manufacture of water-tube boilers, Babcock and Wilcox were well placed to tackle these problems. In fact, the design of the Calder Hall station was chosen to take advantage where possible of existing techniques.

The eight heat exchangers for Calder Hall "A" are welded steel towers 80 ft. high and 17 ft. in diameter, each containing complex banks of steel tubing, some ten miles in length, covered with 11 million electrically welded fins of aerofoil section, as illustrated in Fig. 10, to provide maximum surface for heat-exchange, with minimum resistance to gas flow. Carbon dioxide gas, raised to a high temperature in the nuclear reactor, is passed under pressure over these heat-exchange surfaces, converting the water circulating through the multiple-tube banks into superheated steam which drives the turbo-alternators. Transport considerations made it necessary to construct the towers in sections at the company's Renfrew works, these sections being taken to Calder Hall by road and welded together on site. The base section of a tower is shown in Fig. 8. After this they were stress-relieved and subjected to hydraulic tests before erection. After erection, the multiple finned-tube sections of the heat-exchanger banks were delivered to site in sealed containers and assembled inside the towers under exceptionally strict conditions of cleanliness and precision. The scores of connections between the tube sections forming the heat-exchanger banks were all made externally to the tower shells, by butt-welding, in such a way as to exclude internal leakages of gas, steam or water that could interfere with the proper functioning of the plant. This is achieved by means of thermal sleeves, which pass through the heat-exchanger shells, and through which the ends of the tube elements emerge. Thermal sleeves are shown being welded on a heat-exchanger section in Fig. 9. Fig. 11 shows a complete heat exchanger as it appears in the finished station. The contract with Babcock and Wilcox, Limited, included, in addition, the supply of integral pipework and of the 16 high-pressure and 16 low-pressure circulating pumps. These will be covered in another section.

As has been noted, large sections of the heat-exchanger shells, fabricated from 1¼ in. plate, were welded together after arrival at Calder Hall, so that stress relieving had also to be carried out on site. The use of a box furnace for vessels of this size would have been extremely uneconomic, particularly since heating was only required in the region of the welds, and an alternative technique was therefore adopted. This entailed high-frequency induction heating, and equipment for local pre-heating and stress-relieving on site was provided by the *Electric Furnace Company, Limited.* A vertical-axis water-cooled motor-generator set supplies high-frequency current at a maximum rating of 200 kW, and flexible inductor cables carrying this current are wound round the area to be welded and suitably lagged and insulated to conserve the heat induced in the metal. Fig. 12 shows these cables in position. As soon as the area was brought to the required temperature, the weld was made, and slow and controlled uniform cooling was then effected by careful regulation of the power input. The temperature required was approximately 1,150 deg. F. (630 deg. C.), which was reached in 3 hours and thereafter held for 1½ hours. It was then allowed to drop by 360 deg. F. (200 deg. C.) per hour by reducing the power input on a predetermined basis. Two sets of cables were used so that, while one weld was being treated, cables could be placed in position for the next, both outside and inside, together with the necessary lagging.

Insulation is necessarily an important factor in plants where thermal efficiency is an important consideration, and in the case of Calder Hall a number of special problems were involved. The *Darlington Insulation Company, Limited,* worked with both Whessoe Limited and Babcock and Wilcox in devising suitable insulation for reactors, heat exchangers and steam pipework. For these items Darlington 85 per cent. magnesia products—made by the *Chemical and Insulating Company, Limited*—were used, having been tested and found capable of withstanding long exposure to radiation. In addition, Meta-Dextramite was employed, and Darlington Armouring Compound No. 1 was also applied

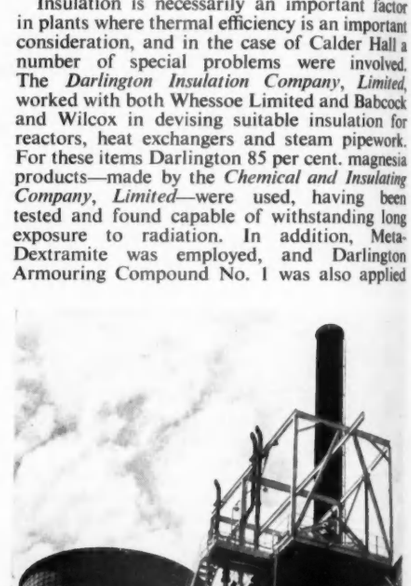


Fig. 11 Two heat exchangers as they appear in the finished station. Four surround each reactor building, making eight in all.

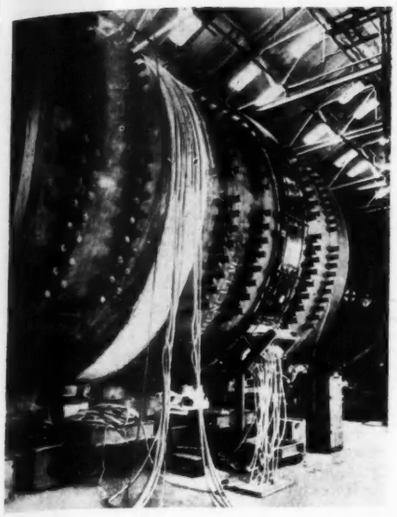


Fig. 12 Welding the sections of the pressure vessel on site entailed special means of stress relieving. This was effected by controlling the rate of cooling after welding by induction heating.

in most places. On the reactor pressure vessels, which are approximately 60 ft. high and 30 ft. in diameter, great care had to be taken so that expansion and contraction could take place without damage to the insulation. It was also necessary to make special provision for supporting the 9 in. of insulation on these large vertical surfaces.

(A list of contractors and their addresses will be given at the end of the article, which is to be continued.)

* * *

SILICON JUNCTION RECTIFIERS

The British Thomson-Houston Company, Limited, Rugby, have recently developed a series of low-power silicon junction rectifiers for applications where high-temperature working is necessary and small sizes are required.

With these rectifiers it is possible to employ a maximum junction temperature of 200 deg. C., thus allowing operation in ambient temperatures up to 175 deg. C. At these high temperatures inverse voltages up to 300 volts are possible. Alternatively, if the maximum junction temperature is limited to 120 deg. C., allowing operation in ambient temperatures up to 100 deg. C., a higher inverse voltage can be obtained. In fact, 400 volt units are being made.

Experimental rectifiers have been made including those with a maximum junction temperature of 200 deg. C. and maximum inverse voltages of 50, 100, 200 and 300 volts. All these types have a maximum mean output current of 0·75 ampere at an ambient temperature of 25 deg. C., of 0·5 ampere at 100 deg. C., and of 0·3 ampere at 150 deg. C. The alternative medium-temperature types have a maximum junction temperature of 120 deg. C. and maximum inverse voltages of 200, 300 and 400 volts. The maximum mean output current is 0·5 ampere at an ambient temperature of 25 deg. C., of 0·3 ampere at 75 deg. C. and of 0·15 ampere at 100 deg. C.

Another application of the silicon rectifier is as a voltage reference (Zener diode), particularly in the range of 4 to 8 volts. Three units of this type have been developed for a maximum junction temperature of 250 deg. C. With a reference voltage of 4 volts the maximum current at an ambient temperature of 25 deg. C. is 0·3 ampere, and is 0·22 ampere and 0·15 ampere at 6 and 8 volts respectively. At an ambient temperature of 100 deg. C. the maximum current at a reference voltage of 4 volts is 0·2 ampere, and 0·15 ampere and 0·1 ampere at 6 and 8 volts respectively.

ATOMIC REVIEW

To-day and To-morrow

Better nuclear power stations—Thicker pressure vessels—Who builds for the C.E.A.?—Reactor progress—Turbo-alternator and fuel-can contracts for Dounreay—Generating plant order for Canada's first nuclear power station—British low-power reactors for export—Lectures in Edinburgh—Domestic Peril.

Projects for the Future

With the successful completion of Britain's first atomic power station, attention turns to other projects planned or in progress. Already the 6 tons of documents forming the tenders for the first two Central Electricity Authority nuclear stations are being studied, and since they were submitted at the beginning of this month speculation on the result has been lively. It is expected that no station proposed will have an output under 300 MW, and a figure as high as 360 MW has been suggested. Estimated capital cost per kilowatt of installed capacity lies between £120 and £150, so that the stations are each likely to entail an expenditure of over £40 million. The stations, which are to be based on gas-cooled graphite-moderated reactors like those at Calder Hall, will be the first two of the four C.E.A. stations due to begin operating before 1963. By 1965 there will be 12 stations (or possibly more) with a total capacity now estimated to be more than 6,000 MW.

The four groups responsible for the tenders are: 1. The A.E.I.—John Thompson nuclear energy company; 2. The Nuclear Power Plant Company (including C. A. Parsons, A. Reyrolle, Whessoe, Head Wrightson, Alex. Findlay, Robert McAlpine and Sons, Strachan and Henshaw, and Clarke Chapman and Company); 3. The English Electric—Babcock and Wilcox—Taylor Woodrow group; and 4. The G.E.C.—Simon-Carves group (which also includes the Motherwell Bridge and Engineering Company and John Mowlem).

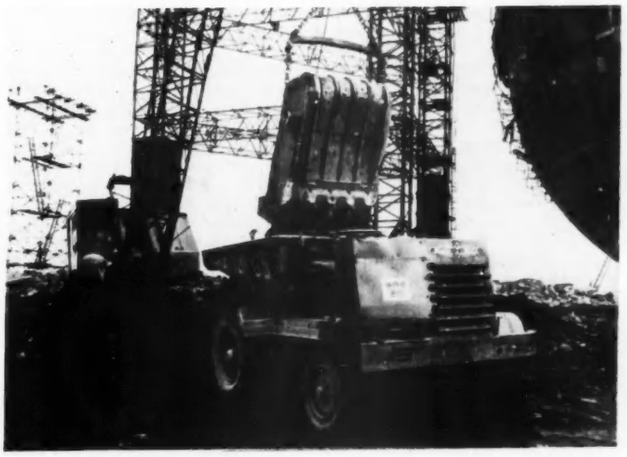
The advance in capacity beyond that of Calder Hall (184 MW for the complete plant comprising stations "A" and "B") is likely to arise from technical developments enabling a greater output to be obtained from a plant of similar size. One of these may be the use of a beryllium alloy sheath for the fuel elements, permitting higher reactor operating temperatures; a similar advance in heat rating may be achieved by use of improved finning for the fuel elements; and another may be the use of reactor pressure vessels of greater thickness.

Pressure Vessel Thickness

A major factor determining the thermal output of a gas-cooled reactor is the gas pressure, since heat removal is dependent on this parameter; this in turn depends on the thickness of pressure vessel that can be welded on site. At Calder Hall the pressure-vessel thickness is 2 in., but it has been reported that English Electric is prepared to at tempt more than 2½ in., G.E.C. and A.E.I.—John Thompson 3 in., and Parsons as much as 4 in. It is worth noting that the Parsons group, who seem prepared to undertake the greatest thickness, includes Whessoe Limited, who have been responsible for the pressure vessels at Calder Hall. The successful testing of these vessels and the cautious development work carried out prior to their construction lends confidence to the belief that pressure vessels assembled on sitefrom 4 in. plate sections are now a practical possibility.

Tender Prospects

The question of whether experience gained from working at Calder Hall gives certain groups a formidable advantage is an interesting one. In addition to the pressure vessels, members of the Parsons group have been responsible for the turbines, condensers, gas blowers, fuel charging and discharging equipment, and part of the switchgear; though Babcock and Wilcox of the English Electric group have made a valuable contribution in the heat exchangers. However, the knowledge and experience gained in the design and construction of Calder Hall has been available to all groups through the U.K.A.E.A., and in any case adaption to the new requirements may prove more difficult where techniques have already been established. What is more, preoccupation with this project may have diverted attention and resources from the planning and development involved in preparing designs for the more advanced C.E.A. stations. We have already given some indication of the extensive preparatory work carried out by the G.E.C. and English Electric groups and have noted that G.E.C. is spending half a million pounds a year on atomic energy work. Less has been published concerning the progress of the other two groups, but it is known that A.E.I.—John Thompson are the only group to have their own research reactor—MERLIN. Early next year the C.E.A. are expected to announce the result of this contest, which is to some extent one of prestige since there will be abundant atomic energy work to be undertaken once the programme is under way. There is, for example, the station to be built for the South of Scotland Electricity Board; tenders are expected by the end of this year. It is understood that this station will be built at Hunterston near Largs in Ayrshire at a cost of £35 million, and will have a total capacity with two reactors of between 250 and 300 MW. A representative of A.E.I.—John Thompson is reported as saying that the cost might well be £20 per kW of installed



Dumper trucks have been used extensively for clearing the site where the Dounreay fast breeder reactor is under construction. A pit 120 ft. long by 110 ft. wide by 40 ft. deep has been excavated for active-liquor storage.

capacity less than that of the C.E.A. stations, which are to be built on sites subject to flooding.

It should be noted that there are other groups and companies beside these four which are interested in atomic energy work. Some, like Vickers Nuclear Engineering Limited (in which Rolls-Royce Limited and Foster Wheeler Limited are co-operating) and Richardsons, Westgarth Atomic Limited, are probably concerned mainly with propulsion, but there are others like the Mitchell group who are interested in power stations, though not necessarily of gas-cooled design. (Mitchell Engineering Limited, which is associated with the American firm A.M.F. Atomics Incorporated for this work, have undertaken to build boiling-water reactors.)

Advanced Reactors

However, it is likely that in Britain at least the gas-cooled graphite-moderated reactor, which recent news tends to confirm as a wise choice, will probably hold its own for a considerable period. Mr. Kenneth Jay of the Atomic Energy Research Establishment, Harwell, has suggested that the electrical output of later plants may be increased three or four times without adding more than 10 or 15 per cent. to the cost of construction. A station of 360 MW might then cost less than £20 million to build, as against the £40 million quoted above, though this depends on the size of station which it will be most economic to operate. Subsequently, reactors using pressurised water as coolant and moderator or based on the sodium-graphite system, giving electrical outputs in the region of 500 MW, may begin to play their part, and plutonium produced in the earlier piles will be available as fuel enrichment.

In addition, work is at present in progress on Calder Hall " B " and a station of the same kind at Chapel Cross in Dumfriesshire, with Merz and McLellan as civil engineering consultants. The erection near Thurso, Caithness, of the Dounreay fast breeder reactor due to begin operating early in 1958, is also proceeding rapidly; the lower half of the protecting sphere has been finished for some time. By March this year the floor of the vault was complete and the steel work for the walls had been erected; since then construction of the upper half of the sphere has begun. Fabrication of the heat exchangers by John Thompson Limited has been under way at least since the beginning of this year. The reactor will produce 60 MW of heat giving an electrical output of 15 MW.

Contracts for Dounreay

Several contracts have recently been awarded for the Dounreay project. One of these, for the turbo-alternator, has been placed with the General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2. The 15 MW steam turbo-alternator is to operate initially under steam conditions of 150 lb. per sq. in. gauge and 270 deg. C. (518 deg. F.), and the alternator, which will be a three-phase 50 cycle machine, will generate at 11 kV. The Motherwell Bridge and Engineering Company, which is associated with G.E.C. through the G.E.C.—Simon-Carves Atomic Energy Group, is building the 135 ft. diameter reactor containing sphere.

A contract has also been awarded to Accles and Pollock Limited, of the Tube Investments group, The Adelphi, London, W.C.2, who are to make the reactor's fuel-element sheaths. The order, which requires the production of niobium (or columbium as it is sometimes known) and vanadium tubes to extremely fine tolerances is believed to be the first instance of these metals being fabricated in other than experimental quantities.

Excavation and clearing operations on the Dounreay site have been carried out with the aid of Muir-Hill dumpers. Construction of highly active liquor storage facilities on the site called for excavation of underground space measuring 120 ft. by 110 ft. by 40 ft. This involved the removal of 20,000 cub. yds. (approximately 30,000 tons) of rock—mainly sandy Devonian limestone—which had to be transported by Muir-Hill dumpers, a distance averaging 200 yd. One of the dumpers is shown on the Dounreay site in the illustration on page 505. Excavation was carried out by a 33R.B. excavator, of 1¼ cub. yd. shovel size, and a shuttle service of four 4½ cub. yd. Muir-Hill gravity tipping dumpers. After initial test excavations, output reached approximately 2,400 cub. yd. of blasted rock each week (some 400 cub. yd. per day). The contractors are Whatlings Limited.

Canadian Nuclear Power Station

Atomic energy work undertaken by British firms is not limited to this country; a contract for electrical generating plant worth 620,000 dols. (£224,000) has recently been placed with the Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, 17, for Canada's first nuclear power project (see ENGINEERING, September 28, page 414, 1956). The power station, which is to be known as the Nuclear Power Demonstration plant (NPD) and will be owned by the Ontario Hydro-Electric Power Commission is to be operated as part of their 230 kV system, and will be situated at Des Joachims on the Ottawa River nearly 150 miles north-west of Ottawa. It will comprise a nuclear reactor (to be built by the Canadian General Electric Company, to the design of Atomic Energy for Canada, Limited), boiler plant, and generating plant with an output of 20MW. The Metropolitan-Vickers contract covers a 20MW 3,600 r.p.m. turbo-generator set with associated condensing and feed-water heating plant, all of which will be made at the company's works at Trafford Park and Germiston. The turbine is designed to take dry saturated steam at a pressure of 400 lb. per sq. in. gauge, and an interesting feature is that, despite the low inlet steam conditions, the wetness at exhaust is no greater than is normal on sets operating at much higher pressures and temperatures. The generator is air cooled and operates at a power factor of 0·85, generating at 13·8 kV three-phase 50 cycles per second. This nuclear power station, which will cost some 14 million dols. (£5 million), is expected to be in commission by July, 1959, and the Metrovick plant is to be ready for operation by March of that year.

Package Reactors

Also of interest is a report that A.E.I.—John Thompson (of which Metropolitan-Vickers are a member company) are to take part in the construction of at least one of two experimental 10 to 15 MW power reactors to be built for the U.K.A.E.A. in 1957. These, it is said, are to be prototypes for potential low-power export atomic power stations.

Notice

An advanced course on " Power Generation by Nuclear Reactors " is to be given at the Heriot-Watt College, Edinburgh, on six successive Saturday mornings from October 20, 1956. The lectures, which have been arranged by the Department of Electrical Engineering and will be held from 9.30 a.m. until 12 noon, will be given by five speakers, including Dr. A. B. McIntosh of the U.K.A.E.A. Industrial Group, who will talk about materials, and Dr. J. M. Kay, Professor of Nuclear Power at the Imperial College of Science and Technology, who will discuss reactor construction.

Postscript

James Thurber says that his mother considered it dangerous to drive an automobile without gasoline—" it fried the valves or something." To her, gasoline, oil and water were much the same, a fact that made her life both confusing and perilous. With the news that atomic power had reached the kitchen, her existence would have become still more hazardous, with newspaper cartoonists adding to her confusion. (" That," says a housewife pointing to a little mushroom cloud poised above the cooker, " is your dinner.") Fortunately, as we are reassured by another paper, it's the same electricity wherever it comes from. This would have been small comfort to another of Mr. Thurber's female relatives, who went around screwing electric light bulbs into empty sockets, convinced that electricity was leaking all over the house. Nowadays, of course, we know better; the menace comes from radiation leaking out of television sets.

SELECTIVE ELECTRIC LOAD DEVELOPMENT

In an address which, as chairman, he delivered to the Utilisation Section of the Institution of Electrical Engineers on October 11, Mr. H. J. Gibson of the Midlands Electricity Board analysed the load curves of the main classes of electricity consumers and pointed out that while each group had characteristic irregularities, these were to a considerable extent complementary. It was also apparent from the composite curve that there were periods during the day to which existing applications might be extended or new ones introduced with benefit. The low usage of all groups during the night also invited attention.

Mr. Gibson gave a number of examples to show how the maximum use of capital plant and the progressive improvement of load factor could be achieved. These included the greater use of the electric arc furnace for the production of lower grade steel; and the present trend was for these to supersede the open-hearth process. The load factor of a 50 ton furnace was about 35 per cent., but the cycle of operation required a high demand during the melting period and a much lower demand during the soaking period. If, however, the working cycles of two or more furnaces were staggered, the maximum demand could be kept at a reduced figure for certain periods, so making a special tariff possible.

In most factories the greatest use of electricity was for motive power and, although it was possible to design a system to operate at a power factor as high as 0·85, this was seldom achieved in practice. Plant, cables and switchgear must, as a result, be of greater capacity and more expensive than they need be. To make the fullest use of capital equipment, users should instal power factor correction equipment, a step which was encouraged by the Area Boards' tariffs and would pay for itself in a short period.

Electric process heating was expanding at a remarkable rate, one of the most outstanding examples being a new type of electrically fired intermittent pottery kiln. By the use of high-grade insulating fire-bricks with low heat-storage capacity, and by employing heating elements of special alloy supplied at 90 volts, these kilns could be operated at temperatures up to 1,300 deg. C., and a load factor of 90 per cent. was attainable. The running cost was only just over half that of the coal costs for the older type of kilns.

One of the obligations of the Area Boards was to extend an electricity supply to country areas and to make the maximum use of capital expended on mains and substations it was necessary to encourage industries having some association with rural activities to establish factories remote from industrial and urban centres and adjacent to distribution lines. An example of this was a factory at Coleford in the Forest of Dean where the production of fruit extracts was carried on under the most modern hygienic conditions. The monthly maximum demand averaged 280 kVA and the annual consumption of over one million kilowatt-hours resulted in a load factor of about 33 per cent., the average cost being 1·135*d.* per kilowatt hour.

For many years, concluded Mr. Gibson, engineers had been seeking ways of increasing the consumption of electricity during the night. The most promising applications were those which would store energy during the night for use during the day. The circumstances warranted a specially low tariff and the capital involved was usually less than for alternative methods.

FISHERMAN'S ASDIC

NEW DEVELOPMENTS IN SHOAL LOCATING

Although the development during the last 20 years of echo-sounding equipment specifically for fish location has substantially increased the productivity of the world's fishing fleets, there is still much time spent on unproductive searching since the echo-sounding equipment only indicates the presence of a shoal when the fishing boat is vertically above it. To minimise this unproductive time, Kelvin and Hughes (Marine), Limited, 99 Fenchurch-street, London, E.C.3, have for the past 10 years been experimenting with Asdic—horizontal ranging using acoustic pulses—and some three years ago they announced the successful development of their Echo Whalefinder (ENGINEERING, vol. 175 page 90 1953). This equipment is now installed in some 50 whalers, and every year more vessels are adopting it.

The application of Asdic to pelagic fish detection has proved rather more difficult than to the finding of whales, which are large and concentrated objects. The problems have, however, been satisfactorily overcome, and following extensive sea development trials by fisheries research ships, Scottish ring-netters and Norwegian fishing vessels, Kelvin and Hughes have produced the "Fisherman's Asdic"—a combined echo-ranging and echo-sounding equipment for detecting shallow and mid-water shoals down to about 100 fathoms, with an operating range up to 2,000 yards.

As indicated in Fig. 1, the equipment comprises a hull unit, a wheelhouse control unit with a separate loudspeaker, and a rotary converter providing the alternating power for the equipment from a 24 volt or 110 volt direct-current supply. The hull unit consists of a retractable transducer head. The echo-ranging transducer has a frequency of 50 kilocycles per second, and transmits a pulse beam tilted 5 deg. down from the horizontal; the horizontal beam angle is 12 deg., and the vertical angle can be varied from 20 deg. to 10 deg.

The echo-sounding transducer, which is brought into action in place of the horizontal transducer when the ship is over the shoal, also has a frequency of 50 kilocycles, and produces a downward pulse train with beam angles of 22 deg. by 17 deg.

In operation, the transducer is lowered by the retracting mechanism, and is rotated from beam to beam either under manual control, or automatically in steps of 5 deg., each advance being made just prior to transmission of a pulse. Echo pulses reflected from any object in the path of the beam are picked up by the same transducer and are amplified in the common transmitter-receiver system incorporated in the wheelhouse control unit. This unit houses all the operating controls and the recorder chart. Three range scales and two sounding scales are provided, and three chart-paper speeds are available for each range scale. When initiating a search, it is usual to run the equipment with the paper feed stopped, for economy in paper, using the loudspeaker to detect the first shoal echoes. The chart shows only range data: bearing values are taken from a separate dial on the control unit. From the downward component of the ranging pulses, bottom echoes are shown on the chart as well as echoes from fish shoals; this has been found to help in interpreting the results. When the day's search is completed, the transducer is retracted into a protective housing, there traction time being 7 seconds. The mechanism comprises an electric motor and drive chain with stops at the upper and lower limits of travel. Provision for dynamic braking of the motor at the limits is incorporated.

For transmitting the acoustic pulses, both ranging and sounding, a four-valve transmitter is used giving both 1 and 10 milli-second pulses, the long pulses being for echo-ranging only. The pulsed power output is 1 kW. A high-gain amplifier with automatic reverberation gain control is employed.

Kelvin and Hughes (Marine) Limited have also recently introduced improved, more economical, echo sounding equipment both for mid-water and deep-sea fishing. The M.S.28 Fishmaster is a standard recording echo-sounder for pelagic fishing generally, with a selection of four alternative scale ranges from 0-30 fathoms to 0-120 fathoms. For demersal fishing up to 480 fathoms depth, the higher powered M.S.29 Fishmaster is offered, intended for use with cathode-ray-tube "scale expander" viewing units. Two new viewing units for use with M.S.29 are available—a compact 3 in. tube, and a 5 in. tube for the deep-sea trawler.

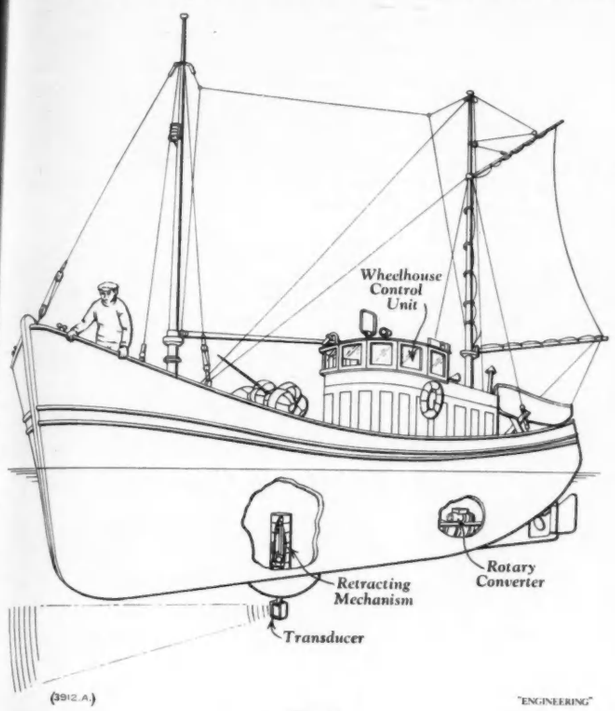
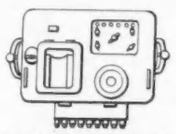


Fig. 1



ENLARGED DETAIL OF WHEELHOUSE CONTROL UNIT

Fig. 2

Fig. 1 "Fisherman's Asdic" installation in a herring drifter. This equipment makes possible for the first time echo-ranging for pelagic fish detection. Fig. 2 The retracting mechanism for the transducer head, which incorporates both echo-ranging and echo-sounding transducers.

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CONTROLLED FEED MACHINE

The Schaffer Poidometer

A machine for continuously feeding raw materials at a predetermined constant rate, the Schaffer Poidometer, has been developed by Sheepbridge Engineering, Limited, Chesterfield. The rate of flow can be adjusted during operation to suit changes in requirements. The machine can also be adapted to deliver batch weights of material by using it in conjunction with a timing device.

Standard machines can be supplied to meet any required capacity within the range of 2 tons to 300 tons per hour, in widths of 6 in., 10 in., 14 in., 20 in., 30 in., 36 in. and 48 in. and lengths of 2 ft., 2 ft. 6 in., 4 ft. 6 in. and 6 ft. Basically the machine consists of a fabricated steel frame on which is mounted a flat rubber-belt conveyor driven by an electric motor through a worm-reduction box. Material is fed on to this belt by an integral hopper.

The hopper opening through which the material flows is of inverted V shape and the depth of carpet of material on the belt is determined by the position of a vertical sliding control gate.

Close-spaced support rollers are positioned underneath the hopper, but the main length of the belt receives its support from a single control roller which, by means of a linkage mounted on knife edges, is connected and balanced by a beam which, in turn, is connected to the sliding control gate. The balance beam is graduated in pounds, and is set to deliver the amount of material in pounds required for each foot of belt travel.

A recording device shows the cumulative number of feet the belt has travelled, and this figure, multiplied by the weight shown on the balance beam, enables the operator to ascertain the amount of material handled.

If the weight of material passing along the belt exceeds the pre-determined weight the control roller is depressed and the control gate is lowered, thus reducing the carpet of material. Conversely, if thew eight of material passing along the belt is less than the pre-determined weight the control roller rises and the control gate is lifted, thus increasing the carpet of material.

To assist in free-flowing of certain materials an agitator is fitted in the hopper, driven from the tail shaft of the conveyor. Where these machines are required to deal with fine materials which tend to flood, a non-flood type of hopper is provided, which takes the form of a paddle feeder, controlling the flow of material. When handling coarse material, the control gate is operated by a separate electric motor through a worm box and screw. Simple electric switches operated by the balance beam control this motor. Additional safety limit switches are incorporated to prevent any mechanical damage in the event of faulty adjustment.

Where a wide range of adjustment in capacity is called for, the main belt drive can be fitted with a variable speed unit which in conjunction with the adjustment available with the drop weights on the balance beam will give the range of capacity required.

Accuracy of delivery of the order of plus or minus ½ per cent. can be obtained.

BRITISH AND FOREIGN CAR DESIGN

By Gordon Wilkins

Never in the history of the motor industry have the vehicles on sale covered such a range of size and power as they do to-day. Even if the sports cars are left out of consideration, an international motor show brings together saloon cars with engines ranging from 11 to over 300 b.h.p., weighing from 1,100 to 5,000 lb., and with maximum speeds ranging from 50 m.p.h. to over 120 m.p.h. High tariffs and taxes prevent a full display in London of the remarkable miniature vehicles now being developed on the Continent, which offer performance and comfort in a degree not thought possible a few years ago, and the full range of 1957 American models, with their annual increases in size and power, is not yet announced, although we can see a representative selection at the London Motor Show.

Renault " Dauphine "

Ford " Zodiac "

Hillman " Minx "

Austin A95

Standard " Sportsman "

The British industry has in some ways the most difficult task of all. It has since the war succeeded in exporting as much as 70 per cent. of its output, a figure never reached by anyone else, and is expected to go on doing so. But the early successes inevitably involved taking some risks in the choice of agents and the provision of service facilities, accompanied by a greater concentration of effort on production than on design. The Germans, profiting from our experiences, treating their agents with typical ruthlessness, and backed by government officials not adverse to taking a strong line in demanding quotas and permits, have this year overtaken us as the second largst car producers in the world and the largest exporters. They have not so far had to bear the tax burden of a high defence expenditure, and their labour situation has so far been more tranquil. In Britain, production plans laid years ahead, and backed by multi-million pound investments, may be made nonsensical by a sudden switch in government policy, which restricts the home market, while our best overseas markets may be drastically restricted by their balance-of-payments crises.

The design and production of good modern well finished vehicles which will attract foreign buyers with high living standards can only be achieved by men whose own standards are high, yet our people work in an atmosphere where success is increasingly frowned upon as immoral. (Is there any other country in the world where big companies have to forbid their directors to buy Rolls-Royces ?) The use of cars at home is discouraged not only as a temporary anti-inflationary expedient, but by taxation, legislation and propaganda, with the long-term object of bolstering up inefficient public transport, and sparing the Government from the disagreeable necessity of building roads. The gap between the conditions in which British cars are used at home and overseas is thus widening all the time, imposing a special problem on designers. How have they been meeting it ?

The British low-priced sports car continues to be an outstanding success. Here is a product which has become extremely difficult to sell at home, because of high taxes, insurance, and crowded roads, yet we manage to export in some cases over 90 per cent. of output. The Germans are now making inroads into the market with small Alfa Romeos and Porsches, well finished and at keen prices, but the French have so far made no serious effort.

In the low-priced family market we have lost ground heavily to the Germans. A variety of factors have contributed, but fundamentally the product was not right. Styling was not internationally acceptable. Engines were too small and geared to run too fast in the pursuit of fuel economy and top-gear flexibility at low speeds on British roads, but tending to excessive noise and a high consumption of fuel and oil when used at the cruising speeds prevailing abroad. We have now broken with the fallacy that the smallest engine is necessarily the most economical; high internal friction, plus high pumping and churning losses, made some of them remarkably uneconomical in overseas service.

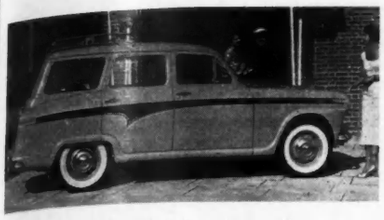
In particular, the Morris Minor, though old, is still acceptable in style and at last has a large enough engine, which in performance and economy should enable it to meet the Volkswagen and Renault Dauphine on equal terms. If its sales still fall short of the hoped-for boom, some of the blame must be borne by slipshod design on the interior, which is notably inferior to that found on the first series several years ago.

Other cars which have been given bigger engines during the year include the Austin A30 (now A35), the Morris Cowley, Wolseley 15/50 and the British-built Nash Metropolitan. Many other models have had their power increased by up to 10 per cent. by increases in compression ratio, and other engine modifications.

Along with the big effort on engines and axle ratios goes a major attempt to make driving easier, in which Britain now has the initiative. It could be particularly important in developing the market for the second family car in the United States, where many people have no experience of manipulating conventional controls, and have no desire to learn. Rolls-Royce, Bentley, Armstrong-Siddeley and the Austin Princess now use the Rolls-Royce derivation of the General Motors Hydramatic, which is heavy and costly but efficient. B.M.C., Rootes and Ford have now followed Jaguar in offering their six-cylinder cars with the British-built version of the American Borg Warner torque converter. It differs from those currently in use in the U.S.A. (with one exception) in having a lock-up clutch on the converter, which should eliminate the appreciable power losses in the cruising condition, but its use with engines only half to two-thirds the size of those used in the United States will presumably mean much more frequent recourse to the planetary gears.

Price remains a difficult problem, as the European manufacturer must ask from two to three times as much as the American for an automatic transmission on a much smaller car. This is inevitable while the total production of cars able to use automatic transmissions remains below the output of one major American manu-

M.G. coupé

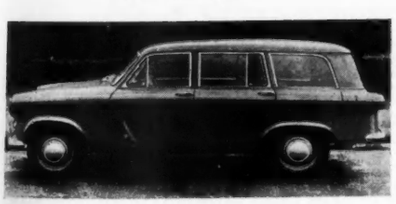


Austin A95 "Countryman"

Peugeot 403 station wagon

"Farnham" conversion of Ford "Consul"

Fiat "Multipla"



Standard "Vanguard" estate car

facturer. With two American transmissions, ageing but still effective, now established in the market, it is to be feared that several promising new European designs now coming forward may fail to find the basis of demand which is essential to launch production on an economic basis.

Price is also a vital factor of the automatic clutches which are now being offered to permit gear changing on ordinary gearboxes without use of the clutch pedal. Standards are providing the Newton centrifugal clutch released by a vacuum servo piston under control of a solenoid worked by a button on the gear lever. It works well and without tax costs only a little over £13. B.M.C. use the Lockheed Manumatic, which not only operates the clutch under the action of a gear lever switch, but takes over control of the throttle during gear changing through the medium of two more servo pistons and a speed-sensitive device on the driven shaft, so as to adjust engine speed and ensure shock-free clutch engagement. Renault have already found it uphill work selling the Ferlex electromagnetic clutch on the 4 CV and Dauphine at about £30, and one wonders how many takers the B.M.C. will find at over £33 plus tax.

There have been several new cars from Britain this year showing attractive modern styling which has been very well received in overseas markets. The three new Fords and the Hillman Minx have achieved a crisp compromise between American and European style that has proved very successful. Other manufacturers have tried to bring existing models into line with world trends by such devices as bigger rear windows, dual colour schemes and hooded head lamps. The Austin A 95 has had an outstandingly successful face-lift, and the Standard Sportsman is a big improvement over the Vanguard. The Austin has a completely new rear end, giving a larger luggage locker and lengthening the car by 10 in., while height has been cut by modifications to the springs.

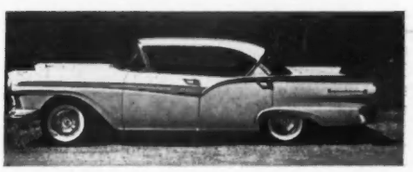
American Ford "Country Sedan"

The lack of closed sports cars has been made good by an M.G. coupé, which is attractive, though somewhat deficient in luggage space. The level of achievement remains very uneven, however, and companies as widely different as the B.M.C. and the David Brown group are now seeking the advice of Italian stylists. This is a sound policy for the immediate future, but several manufacturers have yet to tackle the problem of recruiting and training designers of their own, equipped with taste, discernment, and an understanding of modern production techniques.

France also has relied largely on the improvement of current models during this year, with the outstanding exception of the new Renault Dauphine, now being built at the rate of nearly 600 a day. It has bodywork of attractive modern lines on a longer wheelbase than the 4CV, more passenger space, and more space for luggage than on any rear-engined production model to date. Engine, transmission and swing-axle rear suspension are closely derived from those of the smaller 4 CV, with cylinder bores enlarged to give the engine an extra 100 c.c., and front suspension and steering bear close resemblance to those of the smaller car, but road holding and cornering are vastly improved. The over-steer tendency is reduced, little power seems to be lost in tyre distortion, and it is one of the quickest things on wheels round the sharper type of corner. Remarkably low weight (1,330 lb. dry) may be ascribed partly to the rear engine, but also to cutting down to the minimum on metal gauges and reinforcements where possible, as evidenced by the lack of rigidity in the rear bonnet.

There are also the usual design compromises imposed by the rear engine. The battery takes up space in the luggage locker when it could be very well housed in the engine compartment if it were not for considerations of weight distribution. There is also an unused and unusable space between rear seats and engine compartment. Even so, rear tyres must be run at a pressure 50 per cent. higher than those at the front.

There has been a big extension of interest throughout the world in the station wagon. It now accounts for 10 per cent. of American production and new examples from Europe include the Austin A95, Peugeot 403, two derived from the Vauxhall saloon by coach-builders collaborating with the manufacturers, and one based on the latest Ford Consul. But it is in Italy and Germany that the most radical solutions have been developed to the problem of carrying six people at minimum cost. Germany already has the Volkswagen Transporter, and some still smaller vehicles like the Lloyd are capable of carrying six at 50 m.p.h. and 50 m.p.g., and Fiat have gone for the same market with the Multipla. Using many of the mechanical elements of the Fiat 600 saloon, it has its two front seats over the front wheels, and most ingenious arrangements for folding the four rear seats to give a flat cargo platform. It weighs only 1,540 lb. dry for a payload of 770 lb.



American Ford "Victoria" (Fairlane 500 series)

The new management at Lancia has quickly produced results in the form of a new Flaminia saloon, with mechanical components derived from the Appia, combined with a body based on one of Pinin Farina's most felicitous creations, and an extensive redesign of the little Appia, which was previously too small and too costly to find a ready sale. Otherwise the pattern of Italian production is little changed, and the year has been marked by attempts, not always very happy, to woo the buyer with additions of colour and chromium, accompanied by moderate increases in engine power.

From Germany, the year's main development has been the re-grouping of components to form a series of new Mercedes models: a four-cylinder overhead-camshaft 190 saloon, a 219 with the same body and a six-cylinder engine, and a more luxurious twin-carburetter 220S, all fitted with the single-pivot low roll centre swing-axle rear suspension.

The United States industry is blossoming in a spate of vigorous activity, to boost sales for 1957 after the dip during the current year. Completely new cars for Ford, Mercury and the

Chrysler group, extensive redesign at Chevrolet and Lincoln, and important modifications to Studebaker and the General Motors models have already been announced. The new models are generally long, wide, low, impressive cars with big tail fins. Height has been cut 3 in. or more by reducing wheel diameter to 14 in., by sweeping the frame side members outside the seating area, and by redesigning hypoid axles to drop the propeller shaft still further. Power outputs are increased as usual, so that even the cheapest cars like Ford and Chevrolet can now be had with engines giving over 240 b.h.p. on the bench, giving them a maximum speed of 100 m.p.h. and the ability to accelerate from 0 to 60 m.p.h. in about 10 seconds. Since a large part of the United States highway system is subject to a speed limit of 60 m.p.h., the high maximum speed is a by-product of the search for torque; torque to make good the deficiencies of the automatic fluid transmissions, and give maximum acceleration up to the 60 m.p.h. cruising speed in the "traffic light Grand Prix."

Tail fins have become a dominant style feature, yet despite their high maximum speed, few cars have less need of fins than the Americans. Constantly changing fashions, evolved to keep demand at a high level, leave no scope for drag reduction by serious streamlining, and with a high concentration of weight at the front and marked under-steer, these cars already possess almost excessive course stability. It is the small, lightweight rear-engined cars with some pretensions to streamlining which prove sensitive to side winds, and have most need of tail fins, but so far they have not acquired them.

Lack of weight on the rear wheels has long been an embarrassment to drivers of American cars on slippery surfaces, aggravated by the annual increments of torque. Packard offered a limited slip differential on last season's models, and this example is now being widely followed. Ultimately this problem may oblige American manufacturers to adopt independent rear suspension, or a De Dion axle. This would allow them to move the transmission to the rear, as on the Lancia Flaminia, which would eliminate the big hump that now exists in the front floor, and permit a further reduction in floor height by the use of a divided propeller shaft unaffected by rear wheel deflections.

Most striking external development on next year's American cars is the use of four headlamps instead of two. They are usually of $5\frac{1}{4}$ in. diameter against the normal 7 in. and adequately illustrate the order of priorities imposed on the American automobile engineer by sales departments. More light will permit cars to go still faster at night though their brakes often prove quite inadequate if they are driven to the full.

American innovations on which more information should become available shortly include the launching of fuel injection on a mass-production scale by Chevrolet, using port injection, and a pump sharing a common drive with the ignition distributor, and the use of new coil springs in which the coils compress at an uneven rate to give variable-rate front suspension on the Studebakers. Chrysler have switched all their cars to torsion-bar front suspension, using a system which employs a lower track control arm and a diagonal torque stay very similar to that used for years on the Morris Minor.

To be continued

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THE EFFICIENCY OF BUILDINGS

The purpose of buildings is to protect their occupants, and, in the case of industrial establishments, also plant and machinery, against the vagaries of the weather. How well, or ill, a particular building performs this function may be described as a measure of its efficiency but that quality can hardly be represented by such a specific figure as that by which the efficiency of a machine is usually expressed. However, the term "efficiency of buildings" appears in the Report of the Building Research Board for the year 1955 and may be accepted. The main services required from a building are that it shall be rain- and wind-proof and shall meliorate to some extent the variations in external temperature. The heating and ventilating arrangements and sound-insulating qualities which are embodied in its structure are involved in a measure of its efficiency.

Although the conditions which have to be faced when designing and erecting a building in this country are not so extreme as those present in some tropical countries, there are, none the less, considerable variations throughout Great Britain and it has been suggested that the Building Research Station, in collaboration with the Climatological Division of the Meteorological Office, should prepare a climatological booklet for the building industry on the lines of one being prepared for farmers.

It is stated in the report that about half the research effort available for studies on the efficiency of buildings has been concentrated on problems of thermal insulation, heating and ventilation. In spite of the relatively mild climate of this country, it is obvious that the thermal conductivity of the structure itself will have great influence on the cost and effectiveness of the heating arrangements in houses, schools and hospitals.

On the matter of thermal insulation, the report gives some information about a procedure which would normally be considered a departure from established good practice. It is generally accepted that an 11 in. brick cavity external wall provides better resistance to damp penetration and better thermal insulation than a 9 in. solid brick wall. Some experimental work was, however, carried out in which the void in a cavity wall was filled with glass-wool. The outside of the wall was subjected to a continuous water-spray test for six days without showing any sign of transmitting moisture to the inner leaf and the infill considerably reduced the thermal transmission.

Some information is given about the relative costs of various methods of heating in schools in which only intermittent service is required. An investigation was carried out at Hazelwood School, Abbots Langley, in which two classrooms are heated by warm air, two by radiators and two by floor panels. Automatic control is employed and measurement showed that with the usual night settings the heat consumed by the floor panels was $2\frac{1}{2}$ times and that by the radiators twice that of the warm-air system. With intermittent operation of the floor panels and radiators, the heat consumption for floor panels was $1\frac{1}{2}$ times that for hot air and the consumption for radiators fell between that for floor panels and warm air. Measurement of fuel consumption showed that the average consumptions with coal for hot air and coke for radiators were similar; coal consumptions with radiators and floor panels were 30 per cent. higher. General fuel comparisons showed oil to be competitive with coal but that gas and off-peak electricity cost three to four times as much as coal.

The report does not make specific recommendations about noise control except by implication. It points out that, especially in flats, simple joist floors sometimes specified, decrease airborne sound insulation to 36 dB, as compared with 50 dB for the traditional more massive construction. No doubt the extra expense of heavier construction would be justified in luxury flats but the majority are not of the luxury type. Most of them are let at rents which involve a charge on the general public and any procedure reducing building cost is justified. What is required is the development of a cheap sound insulating method.

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

MANCHESTER
"Atomic Energy: Its Uses and Hazards," by Dr. F. W. Spiers. Ramsey Regional Lecture. College of Technology, Manchester, 1. Thurs., Oct. 25, 7.30 p.m.

British Nuclear Energy Conference

LONDON
"Conduction and Induction Pumps for Liquid Metals," by Dr. L. R. Blake. Institution of Electrical Engineers (from whom advance copies are available), Savoy-place, Victoria-embankment, W.C.2. Thurs., Oct. 25, 5.30 p.m.*

Building Centre

LONDON
Films on "Concreting and Decorating." Wed., Oct. 24, 12.45 p.m.

Chemical Society

EXETER
"Modern Research on Phase Transformations," by Professor A. R. Ubbelohde. Exeter Branch. Washington Singer Laboratories, Prince of Wales-road, Exeter. Fri., Oct. 26, 5 p.m.
GLASGOW
"Metal Atoms as Aromatic Systems," by Dr. J. Chatt. Glasgow Branch. Royal Technical College, Glasgow, C.1. Fri., Oct. 26, 3.30 p.m.
OXFORD
"Sandwich Complexes," by Professor G. Wilkinson. Oxford Branch. Physical Chemistry Laboratory, South Parks-road, Oxford. Mon., Oct. 22, 8.15 p.m.

Illuminating Engineering Society

BIRMINGHAM
"Aerodrome Lighting," by J. W. Morse. Birmingham Centre. Regent House, St. Phillip's-place, Colmore-row, Birmingham. Fri., Oct. 26, 6 p.m.

Incorporated Plant Engineers

CARDIFF
Films on "Steam Raising and Boiler Problems." South Wales Branch. South Wales Institute of Engineers, Park-place, Cardiff. Tues., Oct. 23, 7.15 p.m.
SHEFFIELD
"A Practical Approach to Industrial Electronics," by A. M. Lock. Sheffield Branch. Grand Hotel, Sheffield. Thurs., Oct. 25, 7.30 p.m.

Institute of British Foundrymen

BIRMINGHAM
"Experience in the Use of a Coreless Normal Frequency Melting Furnace," by T. R. Twigger. Birmingham Branch. James Watt Memorial Institute, Great Charles-street, Birmingham, 3. Wed., Oct. 24, 7.15 p.m.
BRISTOL
"Developments in Foundry Sands Practice," by A. Tipper. Bristol and West of England Branch. Grand Hotel, Broad-street, Bristol, 1. Sat., Oct. 27, 3 p.m.

Institute of Industrial Supervisors

LONDON
"The Incentive to Work," by H. T. R. Leonard. London North West Section. Hendon Technical College, The Borroughs, N.W.4. Thurs., Oct. 25, 7.30 p.m.
NEWARK
Discussion on "This is my Job," introduced by J. Green, J. Pepper and L. C. Twigger. Newark Section. Robin Hood Hotel, Newark. Tues., Oct. 23, 7.30 p.m.

Institute of Marine Engineers

BRISTOL
"Gas Turbines," by A. W. Pope. West of England Section. Grand Hotel, Bristol. Mon., Oct. 22, 7.30 p.m.
DUNDEE
"The Junior Engineer's First Trip to Sea," by H. C. Gibson. Scottish Section. Engineering Department, University College, Dundee. Thurs., Oct. 25, 7.30 p.m.
GLASGOW
"The Junior Engineer's First Trip to Sea," by H. C. Gibson. Scottish Section. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Wed., Oct. 24, 7.30 p.m.

Institute of Marine Engineers and Institution of Naval Architects

LONDON
Symposium on "Fires in Ships." Joint Meeting at 85 Minories, E.C.3. Tues., Oct. 23, 10.30 a.m. and 2.30 p.m. With a whole-day visit to Portsmouth on Wed., Oct. 24.

Institute of Metals

BIRMINGHAM
"Dry Corrosion," by E. C. Williams. Birmingham Local Section. Birmingham Exchange and Engineering Centre, Stephenson-place, Birmingham. Thurs., Oct. 25, 6.30 p.m.
SHEFFIELD
"Bessemer and His Process," by J. Mitchell. Sheffield Local Section. The University, St. George's-square, Sheffield, 1. Mon., Oct. 22, 7.30 p.m.

Institute of Refrigeration

LONDON
"Problems of Oil Separation in Refrigeration Equipment," By I. F. Eyles. Junior Institution of Engineers, 14 Rochester-row, S.W.1. Thurs., Oct. 25, 5.30 p.m.*

Institution of Civil Engineers

LONDON
"Skidding Resistance of Roads and the Requirements of Modern Traffic," by C. G. Giles. Road Division. Tues., Oct. 23, 5.30 p.m.*

Institution of Electrical Engineers

LONDON
Talks on "The Use of Transistors in Radio and Television," by Dr. A. J. Biggs and E. Wolfendale. Radio and Telecommunication Section. Mon., Oct. 22, 5.30 p.m.*
Discussion on "The Use of Electronic Computers in Nuclear Reactor Design Studies," opened by R. W. Sutton. Measurement and Control Section. Tues., Oct. 23, 5.30 p.m.*
Chairman's Address on "Engineering Efficiency, Economics and Expediency," by P. J. Ryle. Supply Section. Wed., Oct. 24, 5.30 p.m.*
BIRMINGHAM
Discussion on "Transistors," opened by Dr. D. D. Jones. South Midland Centre. Birmingham Exchange and Engineering Centre, Stephenson-place, Birmingham. Fri., Oct. 26, 6.30 p.m.*
CHELMSFORD
Chairman's Address on "The Story of the Submarine Cable," by K. W. E. Gravett. London Graduate and Student Section. Public Library, Chelmsford. Thurs., Oct. 25, 7 p.m.

NEWCASTLE-UPON-TYNE
"British Electricity Delegation's Recent Visit to Russia," by N. F. Marsh. North Eastern Centre. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Mon., Oct. 22, 6.15 p.m.
NOTTINGHAM
"Atomic Energy Programme," by R. A. Peddie. East Midland Centre. College of Arts and Crafts, Waverley-street, Nottingham. Tues., Oct. 23, 6.30 p.m.
WEYMOUTH
"Breakdown of Electrical Insulation," by J. H. Mason. Southern Centre. South Dorset Technical College, Weymouth. Fri., Oct. 26, 6.30 p.m.

Institution of Engineering Designers

LONDON
Presentation of Awards. Manson House, 26 Portland-place, W.1. Sat., Oct. 27, 3 p.m.

Institution of Engineers and Shipbuilders in Scotland

GLASGOW
"Some Aspects of Ship and Propeller Experiments," by Professor A. M. Robb. Tues., Oct. 23, 6.30 p.m.*

Institution of Locomotive Engineers

LONDON
"Experiences with Diesel Railcars," by M. J. Devereux. Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, S.W.1. Wed., Oct. 24, 5.30 p.m.*

Institution of Mechanical Engineers

LONDON
Discussion on "A Review of Exchange Arrangements for Engineering Students." Education Group. Tues., Oct. 23, 6.45 p.m.*
"Principles and Applications of Hydrodynamic-type Gas Bearings," by G. W. K. Ford, D. M. Harris and D. Pantall. Meeting in conjunction with the Applied Mechanics and Lubrication Groups. Fri., Oct. 26, 6 p.m.*
SHEFFIELD
"Hydraulic Accumulators," by J. G. Frith. Yorkshire Branch. The University, St. George's-square, Sheffield. Wed., Oct. 24, 6.30 p.m.
SLOUGH
Graham Clark Lecture, repeated, on "The Engineer's Contribution to the Conservation of Natural Resources," by Sir Harold Hartley. Eastern Branch. Good Companions Hotel, Slough. Tues., Oct. 23, 7.30 p.m.
SWANSEA
"Pressurised Water Reactor as a Source of Heat for Steam Power Plants," by Dr. J. M. Kay and F. J. Hutchinson. South Wales Branch. Royal Institution of South Wales, Victoria-street, Swansea. Tues., Oct. 23, 6 p.m.

Institution of Production Engineers

LONDON
"Plastic Moulding: Materials, Moulds and Moulding Processes," by J. Butler. London Graduate Section. Wed., Oct. 24, 7.15 p.m.
BANBURY
"Aluminium as a Packaging Material," by J. A. Ambler. Oxford Section. North Oxon Technical College, Bath-road, Banbury. Tues., Oct. 23, 7.30 p.m.
CARDIFF
"Punched Cards System as an Aid to Production," by A. E. Parish. South Wales Section. South Wales Institute of Engineers, Park-place, Cardiff. Fri., Oct. 26, 7 p.m.
HALIFAX
"Application of Accurate Measurement to Engineering Production," by J. Loxham. Halifax Section. White Swan Hotel, Halifax. Mon., Oct. 22, 7.15 p.m.
STOKE-ON-TRENT
"Air Photography in Peace and War," by Group Captain F. C. V. Laws. Stoke-on-Trent Section. Grand Hotel, Hanley, Stoke-on-Trent. Mon., Oct. 22, 7.30 p.m.

Institution of Structural Engineers

LONDON
"A Review of the Structural Steelwork in the 'Seraphim' Extensions at Appleby-Frodingham," by S. Richards and N. Lancaster. Thurs., Oct. 25, 6 p.m.*
BIRMINGHAM
Chairman's Address by R. J. Fowler. Midland Counties Branch. James Watt Memorial Institute, Great Charles-street, Birmingham. Fri., Oct. 26, 6 p.m.
CARDIFF
Chairman's Address on "Modern Steelwork Fabrication," by G. E. Cooper. Wales and Monmouthshire Branch. South Wales Institute of Engineers, Park-place, Cardiff. Tues., Oct. 23, 6.30 p.m.
LIVERPOOL
"Construction of a Prestressed Circular Tank in Pneumatic Mortar," by G. B. Smedley. Lancashire and Cheshire Branch. City of Liverpool College of Building, Clarence-street, Liverpool, 3. Wed., Oct. 31, 6.30 p.m.*

Institution of Works Managers

LONDON
"Work Study," by J. B. Kitchin. Annual General Meeting. London Branch. Royal Society of Arts, John Adam-street, Adelphi, W.C.2. Tues., Oct. 23, 7 p.m.
GLASGOW
"Industrial Health," by Dr. John Millar. Glasgow Branch. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Mon., Oct. 22, 7.30 p.m.
LANCASTER
"Man or Machine," by A. P. Young. Lancaster Group. Storey Institute, Lancaster. Thurs., Oct. 25, 7.30 p.m.

Junior Institution of Engineers

LONDON
"Rubber and the Processes of Manufacture," by F. Skelton. Fri., Oct. 26, 7 p.m.*

Manchester Association of Engineers

MANCHESTER
"John Rennie, 1761-1821: A Study of the Life and Work of an Engineer in Georgian England," by Dr. C. T. G. Boucher. Engineers' Club, Albert-square, Manchester, Fri., Oct. 26, 6.45 p.m.

North East Coast Institution of Engineers and Shipbuilders

NEWCASTLE-UPON-TYNE
"A Review of Naval Propulsion Engineering Progress in the Last Ten Years," by Vice-Admiral Sir Frank T. Mason. Literary and Philosophical Society's Hall, Newcastle-upon-Tyne. Fri., Nov. 2, 6.15 p.m.

Royal Aeronautical Society

LONDON
Discussion on "Functional Efficiency of Aircraft," opened by C. Abell and Air Vice-Marshal A. F. Hutton. Tues., Oct. 23, 7 p.m.
"Nuclear Power for Aircraft," by E. P. Hawthorne. Graduates' and Students' Section. Tues., Oct. 30, 7.30 p.m.

Royal Institution

LONDON
Optics in Industry "—II "Composition," by Dr. A. C. Menzies Tues., Oct. 23, 6 p.m.
"Diamonds, Meteorites and the Origin of the Solar System," by Dr. Harold Urey. Fri., Oct. 26, 9 p.m.

Royal Meteorological Society

EDINBURGH
"Atmosphere of Mars," by Dr. R. M. Goody. Scottish Centre. The University, Drummond-street, Edinburgh. Fri., Oct. 26, 5 p.m.*

Royal Statistical Society

SHEFFIELD
"A Simplified Method of Regression Analysis," by Miss W. M. Gibson and G. H. Jowett. Sheffield Industrial Applications Group. Grand Hotel, Sheffield. Thurs., Oct. 25, 7 p.m.

Sheffield Metallurgical Association

SHEFFIELD
"Impressions of Progress in Ceramic Technology," by Dr. A. T. Green. Grand Hotel. Sheffield. Tues., Oct. 23, 7 p.m.

Society of Engineers

LONDON
"Gas Turbines in Theory and Practice," by D. F. Collins. Geological Society, Burlington House, Piccadilly, W.1. Mon., Nov. 5, 5.30 p.m.*

Society of Industrial Engineers

PORTHCAWL
Conference on "Work Study and Industrial Engineering in Small and Medium-Sized Organisations." Organised in association with the Work Study Society. Esplanade Hotel, Porthcawl. Fri., Oct. 26, 8.30 p.m., and Sat., Oct. 27, 9 a.m., 2 p.m. and 8.30 p.m.

Society of Industrial Radiology

LONDON
"Welding and Inspection of High-Pressure Pipes," by J. H. Webborn. London and Home Counties Branch. British Institute of Radiology, 32 Welbeck-street, W.1. Fri., Oct. 26, 7 p.m.

Society of Instrument Technology

CHESTER
"pH and Its Measurement," by J. C. Farquhar. Chester Section. 5 King's Buildings, King-street, Chester. Wed., Oct. 24, 7 p.m.
GLASGOW
"A Flexible Electronic Recorder Controller," by S. A. Bergen. Scottish Section. Building Centre, 425 Sauchiehall-street, Glasgow. Fri., Oct. 26, 7.15 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

* An asterisk is placed where it is understood that tea is available prior to the time stated.

Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
British Nuclear Energy Conference, 5-7, Great George-street, London, S.W.1. (WHItehall 4577.)
Building Centre, 26 Store-street, London, W.C.1. (MUSeum 5400.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Illuminating Engineering Society, 32 Victoria-street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 48 Drury-lane, Solihull, Birmingham. (Solihull 3021.)
Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester 3. (Blackfriars 6178.)
Institute of Industrial Supervisors, 24 Albert-street, Birmingham 4. (Midland 6971.)
Institute of Marine Engineers, 85 The Minories, London, E.C.3. (ROYal 8493.)
Institute of Metals, 17 Belgrave-square, London, S.W.1. (BELgravia 3291.)
Institute of Refrigeration, New Bridge Street House, New Bridge-street, London, E.C.4. (CENtral 4694.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineering Designers, 38 Portland-place, London, W.1. (LANgham 8847.)
Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. (Central 5181.)
Institution of Locomotive Engineers, 28 Victoria-street, London, S.W.1. (ABBey 6672.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St.James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Naval Architects, 10 Upper Belgrave-street, London, S.W.1. (SLOane 4622.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Institution of Works Managers, 67-68 Chandos-place, London, W.C.2. (TEMple Bar 8324.)
Junior Institution of Engineers, Pepys House, 14 Rochester-row, London, S.W.1. (VICtoria 0786.)
Manchester Association of Engineers, 18 Booth-street, Manchester 2. (Central 1717.)
North East Coast Institution of Engineers and Shipbuilders, Bolbec Hall, Newcastle-upon-Tyne 1. (Newcastle 20289.)
Royal Aeronautical Society, 4 Hamilton-place, London, W.1. (GROsvenor 3515.)
Royal Institution, 21 Albemarle-street, London, W.1. (HYDe Park 0669.)
Royal Meteorological Society, 49 Cromwell-road, South Kensington, London, S.W.7. (KENsington 0730.)
Royal Statistical Society, 21 Bentinck-street, London, W.1. (WELbeck 7638.)
Sheffield Metallurgical Association, 66 Ringstead-crescent, Sheffield 10. (Sheffield 62144.)
Society of Engineers, 17 Victoria-street, London, S.W.1. (ABBey 7244.)
Society of Industrial Engineers. Apply to 15 Alder-avenue, Ystradgynlais, Swansea Valley.
Society of Industrial Radiology, 2 Tomswood-terrace, Barkingside, Essex. (HAInault 5488.)
Society of Instrument Technology, 20 Queen Anne-street, London, W.1. (LANgham 4251.)

The Holman Tractair, which consists of a combined tractor and compressor can be used with a great variety of pneumatic equipment, particularly where portability is desirable.

HOLMAN PORTABLE COMPRESSORS

Tools with a Great Variety of Uses

The accompanying illustration shows a combined tractor and compressor, which is being built by Holman Bros., Limited, Cambourne, Cornwall, for such purposes as road breaking and pipe laying. For carrying out this work a variety of pneumatic tools are available, such as rippers for breaking, spaders for trenching, and backfill rammers for finishing the operation. The unit can also be used for operating drainage pumps as well as in conjunction with a Muledozer attachment for earth moving and similar work.

The Tractair, as it is known, consists essentially of an air-cooled air compressor with outputs of either 71·5 cub. ft. or 110 cub. ft. of free air per minute at a pressure of either 125 lb. or 100 lb. per sq. in. Both compressors are of the reciprocating type and the air is compressed in two stages by a two-diameter piston with an intermediate intercooler. They are arranged for mounting, as can be seen in the illustration, on the rear of a Fordson Major tractor and are driven from the power take-off shaft of the latter through a V-belt, the speed of the engine being reduced by an air-operated governor when the compressor is not operating at full load.

It should be noted that on the Tractair the compressor is permanently mounted on the tractor, but can be engaged or disengaged from the engine by a hand lever, which can be actuated when the clutch pedal is depressed. When it is desired to leave the tractor entirely free an alternative design, known as the Holpack, is available. This consists of a compressor which is mounted in a welded tubular steel frame. It can be attached in a few minutes to tractors equipped with either a hydraulic or a power-operated lift linkage and is then held in position by an automatic safety catch. When coupled, the compressor is driven through a universal coupling from the power take-off shaft of the tractor and then through a lay shaft, which is carried in ball bearings, and a V-pulley. In this way it has been possible to provide that cushioned transmission which is so desirable in compressor work.

The compressors of the Holpack have the same output as those on the Tractair and the unit can be used for operating similar equipment. Both machines can also be used for powering a whole range of small tools and also for driving welding generators.

THE HUMAN ELEMENT

Political and Economic Planning investigate the employment of graduates—And consider the advantages of a university training—A plea for more effective provision for retirement—Industry tackles the problem of more men than jobs—The Government's proposals for service contracts for workpeople—Adoption of improvements in methods and machinery in dock industry obstructed by casual work.

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Graduates Opt for Industry

The new survey by P.E.P. (Political and Economic Planning) entitled *Graduate Employment* offers few surprises, but it does dot the i's and cross the t's of a good many impressions already held on this subject, and it clothes these in some sort of dimension. From the point of view of industry and the professions, the survey confirms what has been generally thought, namely, that to-day industry takes a large portion of the available supply of graduates.

Half the graduates whose circumstances were investigated did not decide what they would to on graduating until already embarked on their studies, but a significant proportion of those who did decide before going up chose the professions, and, among these, engineering was prominent. Two out of every three undergraduates would not acknowledge any influence in making their choice, but university appointments boards seem to have played a decisive part in late decisions to go into industry. Out of the total graduates for the year 1950, it appears that approximately 4,000 must have gone into industry, about 3,100 into teaching and some 1,150 into the various technical and non-technical branches of the Civil Service. The number of men with first-class honours degrees who went into industry, nearly three out of ten—more than went into the Civil Service or remained at the universities, is noteworthy. Consultant engineering took a high proportion of technologists with first-class honours and, as would be expected, the Scottish universities were heavily represented. The worst showing was made by men chosing to be science and mathematics teachers, of whom no less than 62 per cent. had no more than a third-class or pass degree: surely a serious state of affairs when it is considered that the coming generation of technologists will pass through their hands.

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Prospects for Graduates

It is apparent from the P.E.P. survey that many graduates made late decisions on what they would do after they had gone down. In this respect they were like their pre-war colleagues. Outside the professions, few seem to have developed any particular sense of vocation, even in their late 'teens. Many more than formerly proposed to to into industry and commerce. It may be interesting to consider what the prospects looked like to senior undergraduates. Of those sections of employers who wanted their services (and the premium on a good graduate with a good background was, and still is, very high indeed) industry, the professions and the Civil Service asked for good intellectual qualifications and, in many cases, industry demanded a good school educational background as well.

Again, what were the financial prospects like ? To judge from the survey, graduates with good academic qualifications in any particular career chosen did better than those with poorer ones, but the difference was not very great. Scientists with good first-class honours did particularly well, while men from public or independent schools started at lower salaries than the rest, but travelled more quickly, and a high proportion of these went into commerce. Married men started better than bachelors, probably owing to special provisions in many salary scales. On the whole, starting salaries seem to have had little to do with ultimate prospects. The survey tails off in its efforts to follow the men of 1950, even during the few years which have passed since then, and this seems inevitable. It is, however, highly important, as the survey affirms, to provide good statistics of graduate employment in this age, when so much depends on the right employment of trained minds. It is vital, too, to know where the men have gone and in what directions the prospects look best for those coming after.

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Compulsory Pensions

The urge for security of employment and provision for eventual retirement has become a major factor in people's minds in selecting their employment. Companies anxious to obtain good recruits have offered high superannuation terms. Even the Welfare State offers a council house at a subsidised rent and the prospect of an idyllic existence on an old-age pension of £2 a week. The later is clearly an unattractive proposition, even to unskilled labour, while the more amb tio.s schemes operated by large companies and institutions seriously reduce the mobility of the nation's manpower force.

A Fabian tract has been published advocating a national industrial pension plan, to be financed out of contributions levied according to income. Employers would contribute 5 per cent. of the basic wages of their workpeople (excluding overtime and bonuses) and employees would pay about the same percentage. Under this scheme, all workers would be covered, and, of course, pension rights would not be connected with any particular job. This side of the plan seems to be eminently worthy of discussion, especially in the light of similar schemes which are operated abroad. The rest of the plan seems thoroughly objectionable. It suggests that the funds should be used to finance local authorities and nationalised industries by way of loans. It would be quite wrong to earmark such funds for special purposes or to compromise with the principle that the State remains directly and completely responsible for the administration of the pensi n scheme in all its aspects.

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Remedying Redundancy

This need for more secure conditions of employment for wage-earners is generally recognised. The search for security, which seems now to have taken priority over that for higher earnings, began in the United States, where it was pressed with great vigour and much success by the automobile and steel workers unions. It was sparked off by the revolution at present taking place—at a faster rate than most people had dared to forecast—in manufacturing techniques. In Britain, it was the motor industry that first declared workers redundant, through a combination of both automation and falling demand for cars, and the first to conclude agreements with the unions on length of notice, compensation payments and the like.

A constant pre-occupation of companies negotiating such agreements must be their ability to honour them in case of a slump, for a man can only retain his job so long as his employer can afford to pay him. Yet several companies have latterly concluded agreements which commit them to long periods of notice and substantial compensation payments. All are based on length of service and, in this respect, differ radically from the agreements recently concluded in the United States, where it plays only a minor part. The British Cycle Corporation (a subsidiary of Tube Investments Limited) have agreed upon two weeks notice for up to two years service; extending to four weeks for over ten years service, and with compensation of up to ten weeks pay for long-service employees. This stands about halfway between the terms agreed upon by the British Motor Corporation and those proposed by the Birfield group of companies.

Moves are afoot to negotiate a national agreement on redundancy in the engineering industry, and the Engineering and Allied Employers' National Federation have set up a special committee to study the question. It remains to be seen whether the unions will co-operate, or object, on the grounds that they do not want to be restricted " to what a backyard foundry can afford."

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Recognition for Long Service

The Government, also, have taken a hand in the promotion of security of employment for wage earners. This they have done by resurrecting a ten-year-old " industrial charter " which proposes the institution of service contracts between firms and their employees. The Tories, Mr. Iain McLeod argued, want orderly management of the labour market, and, one suspects, not too many such one-way agreements as that put forward recently by the Birfield group (The Human Element, " Cushion for Redundancy," last week, page 480). Mr. McLeod, speaking with all the authority of a newly-appointed Minister of Labour, told the Llandudno delegates that " there should be a recognition that a firm owes greater loyalty to its old faithful servants than to those who have come lately to its payroll." But, he said, this should not be a one-way traffic. The reverse applies equally and it is inconceivable that an employee who has for years been well treated by his company should be able to walk out without even the feeling that he also owes the management some loyalty. The solution, then, lies in a system of service contracts, which would relate the period of notice to be given to the length of service of the employees concerned. The Government have passed the ball over to the employers' organisations and the unions. Any agreement that emerges from the discussions will, " if necessary " be embodied in a Bill to be put before Parliament.

In considering the political approach to the problem of security it is well to remember that the need for it is two-fold: to protect workers from sudden dismissal when sales fall off (at present looked upon almost as an Act of God) and to make possible a smooth transfer of labour, with suitable provisions for retraining those concerned when automatic methods of production are introduced. In both cases, there is a great deal to be said for settlements at company level, where the special problems involved can best be understood, and the responsibilities most clearly defined.

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Casual Employment Condemned

The system of casual dock labour in British ports was attacked by Mr. Francis Cave, general manager of the Mersey Docks and Harbour Board, in his presidential address to the Institute of Transport, delivered last week. Mr. Cave considers that casual employment breeds a feeling of insecurity among workers which is a serious obstacle to the adoption of improved methods and modern machinery. The fear that a job might not be there to follow the one on hand is, in his view, a direct incentive to restrict output. He pointed out that the industry was affected by disputes far more than any other, the hours lost through stoppages during the lifetime of the National Dock Labour Board being 3½ times as many as in shipbuilding, four times as many as in coal mining and nearly 20 times as many as in engineering. The men's feeling of insecurity was such that it was enough for someone to go from ship to ship calling " all out " to start a general stoppage.

Mr. Cave proposed that the industry should be re-organised in worker units of not more than 2,000 men each, which would engage men on a weekly basis. " The port industry is too important to remain indefinitely at the mercy of casual employment," he said, but pointed out that he could see no desire for a change " in any section of dock land at the moment."